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N. Y. STATE DEPARTMENT OF HEALTH

February 1936

TECHNOLOGY REVIEW

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THE TABULAR VIEW

BEFORE the arcana of modern physics the layman stands bewildered, and rare is the expositor who can interpret for him the mysteries of atomic research. In evidence that such expositors do exist, we present this month PHILIP M. MORSE, whose lucid and clarifying article on the neutron appears on page 179. Dr. Morse, an Associate Professor in the Institute's Department of Physics, is a graduate of the Case School of Applied Science and recipient of a doctor's degree from Princeton. While at Princeton he published numerous papers, several of which were in collaboration with President Karl T. Compton, on theoretical interpretation and mathematical formulation of phenomena of discharges through gases. He is the author of several important theories dealing with the spectra, dissociation and energies of chemical molecules, and is co-author of the first book in English on wave mechanics. In the year 1930 to 1931 he was at the University of Munich as an International Research Fellow. ¶MAYO D. HERSEY, '09, ("The Oil-Shed Fallacy") in November and December delivered ten public lectures at Technology on the mechanics of lubrication. After graduation from the Institute, he held positions as physicist with the National Bureau of Standards and as Associate Professor at the Institute. Since 1922 he has been, successively, physicist in charge of the physical laboratory of the United States Bureau of Mines, chief of the friction and lubrication section of the Bureau of Standards, and mechanical engineer and head of the engineering physics division in the research and development department of the Vacuum Oil Company, Inc. He was appointed research associate in engineering at Brown University in 1934. Among the many professional societies of which he is a member are the American Society of Mechanical Engineers, American Society of Naval Engineers, American Physical Society, Washington Academy of Sciences, Society of Rheology (Vice-President), and the American Petroleum Institute. He has been chairman of the Research Committee on Lubrication of the American Society of Mechanical Engineers and has served on various other committees of this Society and of the National Advisory Committee for Aeronautics.

A YEAR ago The Review published "A Canapé of Conundrums" and so great was the interest manifest by readers in these amusing brain teasers that we commissioned P. J. RULON to confect the new collection which we present on page 184. Sharpen your pencils, or better, your wits, and when you have solved the posers, try them out on your friends. Dr. Rulon is an Assistant Professor in the Harvard Graduate School of Education where his field of instruction includes statistics, test constructions, and educational experimentation. Dr. Rulon sometimes will admit that in 1932 he published a book of brain teasers under the pen name of Julian Longstreet. Perhaps there's some enigma about this pseudonym. ¶Contributors to "The Trend of Affairs" this month include EDWARD S. (*Concluded on page 166*)

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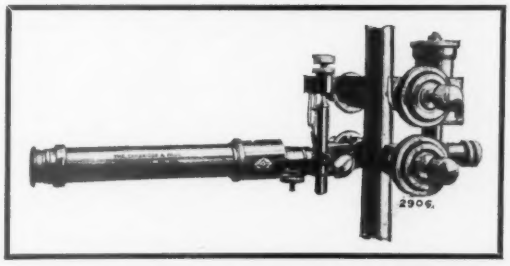

The Ewing Extensometer is used to observe and measure the variation in length of a specimen undergoing tension or compression tests. It is applicable to large or small test pieces and can be used on either vertical or horizontal testing machines. Can be supplied to read in either English or metric units. Readings can be taken to 0.00002 inch. A modified form of this instrument is made for measuring the elastic compression of short blocks having clip centers two inches apart.

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BOSTON, MASS.

THE TABULAR VIEW

(*Concluded from page 165*)

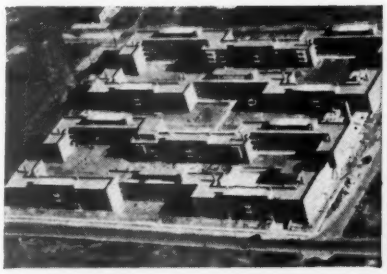
GILFILLAN, JR., Research Associate in chemistry at the Institute and a member of the staff of Arthur D. Little, Inc. ("Oil's Origin"), and FREDERICK G. FASSETT, Assistant Professor of English at Technology ("Extrapolating Existence").

Announcing THE COVER CLUB

PHOTOGRAPHS selected for reproduction on the cover of The Review are held to high standards. They must have attention-getting value, and therefore must be pictorially epigrammatic; they must be adroitly composed to keep the whole cover pattern balanced, and therefore must be carefully studied by the photographer; they must symbolize the contents of The Review, and therefore must relate to science, industry, architecture, or engineering; they must show the familiar in a way the average eye does not normally see it or the unfamiliar in a way that is convincing and telling, and therefore must represent discernment and ingenuity; and they must embody a beauty of their own, and therefore must be imaginative and esthetically satisfying.

Because these standards prevail, the amateur photographer who has a print reproduced on our cover has attained, we like to feel, a measure of distinction in his work that warrants special notice. We propose to give this recognition in this column each month, so far as possible, and by way of doing this, we announce the formation of the Cover Club, the membership of which will include those amateur photographers whose work is printed on the cover. Membership in the Club is limited to amateurs — those contributors who do not make photography their chief business. We thus discriminate against commercial photographers, not because we do not wish to give recognition to the fine work so many of them achieve (we use many prints from professionals), but because the amateur, not working for monetary return, deserves a return in the form of recognition and appreciation. We wish to encourage the amateur photographer, not only to cultivate high standards in his photography, but to submit prints to The Review for consideration as cover subjects (and for use on inside pages, too!).

COVER CLUB member Number 1 is LEWIS P. TABOR, '22, whose photograph of the Philadelphia-Camden Bridge, "Riverfront", graces our jacket this month, and who has other fine prints reproduced in this issue (pp. 172 and 183). Mr. Tabor is head of the Science Department, Episcopal Academy (of which Greville Haslam, '15, is head master), Overbrook, Penna., and in his spare evenings may be found at the Roslyn House Observatory, which explains his star-field pictures, examples of which appear on page 183. The cover photograph, Mr. Tabor reports, was taken with a small camera ($1\frac{5}{8}$ x $2\frac{1}{2}$) and the print reproduced was a bromide. The print has been exhibited by The Miniature Camera Club of Philadelphia.



Carl Mackley Houses, Juniata Park, Philadelphia

HOUSING DEVELOPMENT ATTAINS FUEL ECONOMY

Installation of Webster Moderator System Provides Uniform Heat in PWA Project

REGULATES STEAM SUPPLY

Philadelphia.—For the all-important heating job in the new Carl Mackley Houses, the first of the new, large housing projects actually to be occupied, a Webster Moderator System of Steam Heating was selected.

This group of four buildings is substantially constructed of durable materials—built for long life, with the most modern equipment. It covers an entire block at Juniata Park in the northeastern section of Philadelphia.

The need for a central heating system that would provide healthful comfort free of overheating for nearly 300 families, coupled with the necessity for low annual operating cost, led the engineers to specify the Webster Moderator System of Steam Heating.

The system provides "Control-by-the-Weather," a single Outdoor Thermostat automatically adjusting the steam delivery for changes in outside weather conditions. Accurate orificing of all radiators assures even distribution, all radiators receiving heat at the same time and in amount proportionate to size.

Heating and plumbing plans for the development were prepared by Harry J. Eggly, Jr., Consulting M. E. The installation was made in the fall of 1934, with T. J. Kelly, Inc., acting as plumbing and heating Sub-Contractor, under Turner Construction Co., General Contractors. Architectural plans were made by Kastner & Stonorov and W. Pope Barney.

The financing of the project, including a $1,039,000 loan from the Public Works Administration, was sponsored by the American Federation of Hosiery Workers.

The suitability of the Webster Moderator System for large-scale, low cost housing has led to its adoption in other outstanding developments of this type. Now under installation are Webster Moderator Systems for the Techwood and University Housing Projects in Atlanta, Georgia, both 100 per cent federally financed slum elimination projects.

Lexington Building, Baltimore

STEAM COSTS REDUCED IN 21-STORY BUILDING

Webster Moderator System Helps Baltimore Building to Cut Heating Costs 40 P.C.

ECONOMIES INCREASE YEARLY

Baltimore, Md.—A five-year study of the cost of heating the 21-story Lexington Building reveals the savings possible with the Webster Moderator System after an alert building management has corrected all apparent sources of heat loss.

In two years before Webster Heating Modernization, the management reduced annual steam consumption from 32,800,000 lbs. to 20,400,000 lbs. These savings were accomplished by segregating those portions of the building requiring 24-hour service, shutting off the steam completely in sections when they were not occupied and making a number of small adjustments in steam circulation.

This was the situation prior to heating modernization in the summer of 1930.

With the Webster Moderator System, the Lexington Building used only 16,840,000 lbs. of steam during the ensuing season. With more experience in operation and minor changes in the control equipment, the management further reduced steam consumption to 13,400,000 lbs. in the second season and 12,100,000 lbs. in the third.

The experience of the Lexington Building demonstrates the increasing economies that can be realized year after year with the Webster Moderator System. The management also credits the new system with a marked increase in tenant comfort and a substantial drop in maintenance cost.

Westinghouse Building, Philadelphia

WESTINGHOUSE BUILDING REDUCES HEATING COST

Webster Moderator System Gives Complete Satisfaction, Saves $1,161 in First Year

REDUCTION EXCEEDS ESTIMATE

Philadelphia—The Westinghouse Electric & Manufacturing Company saved more than $1,100 during the 1934-35 heating season by using the Webster Moderator System to control steam distribution in their large Philadelphia building.

The average annual heating cost before modernization, including cost of fuel, labor and maintenance of equipment, was $7,360. During the past season, the total cost was $6,198.38, representing a cash saving of $1,161.62.

The modernization program was undertaken on the basis of an anticipated heating cost reduction of only $693, annually. Commenting on this additional saving and the first year's service with the Webster Moderator System, M. H. Jones, of the Westinghouse Co., said:

"It is very gratifying to me to find that our steam costs under the new arrangement are lower than anticipated. I am convinced that we made no mistake. We feel that most of the credit for the success was due to the efficient operation of your control system."

The Webster Moderator System has provided complete satisfaction and, according to Mr. Jones, should show an increasing economy as the maintenance department becomes more familiar with its operation.

In the Westinghouse Building, three floors are devoted to office space, three floors to service space and the remainder of the building is used for storage. To prevent steam from passing into radiators in the storage section, where heat is not required, solid plates were placed in the radiators. Installed direct radiation now in use totals 26,300 square feet.

The installation was made by Bowers Brothers Co., Philadelphia heating contractors.

If you are interested in (1) improved heating service and (2) lower heating cost in your building, address

WARREN WEBSTER & COMPANY, Camden, N. J.

Pioneers of the Vacuum System of Steam Heating
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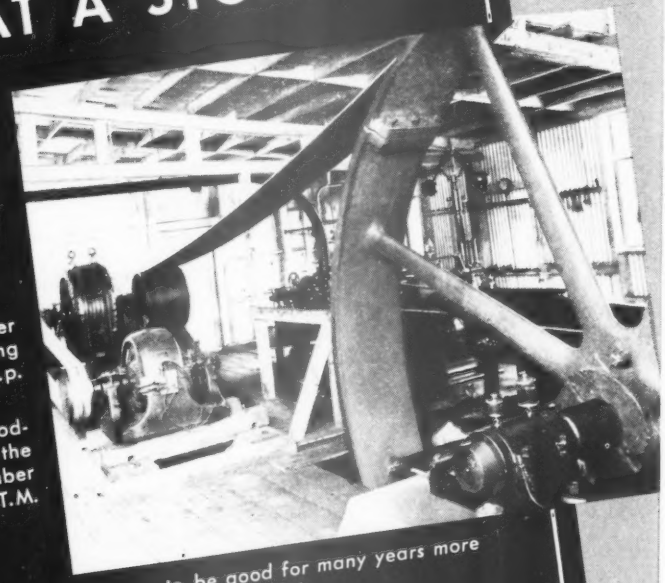
IT DOESN'T LOOK LIKE MUCH ...BUT WHAT A STORY!

especially worth remembering if you buy belting



There is nothing unusual about the power plant pictured here—except the amazing story of the belt running from the 250 h.p. Corliss steam engine to the generator.

Twelve years ago this 34" x 9-ply Goodyear Transmission Belt was installed in the power house of a North Carolina lumber company on the specification of the G.T.M. —Goodyear Technical Man.

Unscathed by fire

For eleven years—a record in itself—it performed faultlessly in this strenuous service. Then, a little over a year ago the mill burned down, but the belt was salvaged.

It was next sold to Claude S. Kinsland, a manufacturer of hardwood lumber, for use in one of his Carolina mills. To fit his service, the belt had to be cut down to 20" width, and it went back to work a year ago on this generator drive.

"Good for many years more"

You wouldn't expect much of a belt after going through these vicissitudes of time, fire and alteration, yet Mr. Kinsland recently reported:

"This belt is giving entire satisfaction and appears to be good for many years more service!" What a belt!

See the GTM

You can expect longer service from Goodyear Transmission, Conveyor and Elevator Belting under most difficult conditions—because all are time-proved products of the world's leading rubber manufacturer—and are individually specified to their job after careful analysis by the G.T.M.

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Iron Works, Corby, England

F. S. Lincoln, '22

THE TECHNOLOGY REVIEW

Title Reg. U. S. Pat. Office

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOL. 38, NO. 5 CONTENTS FEBRUARY, 1936

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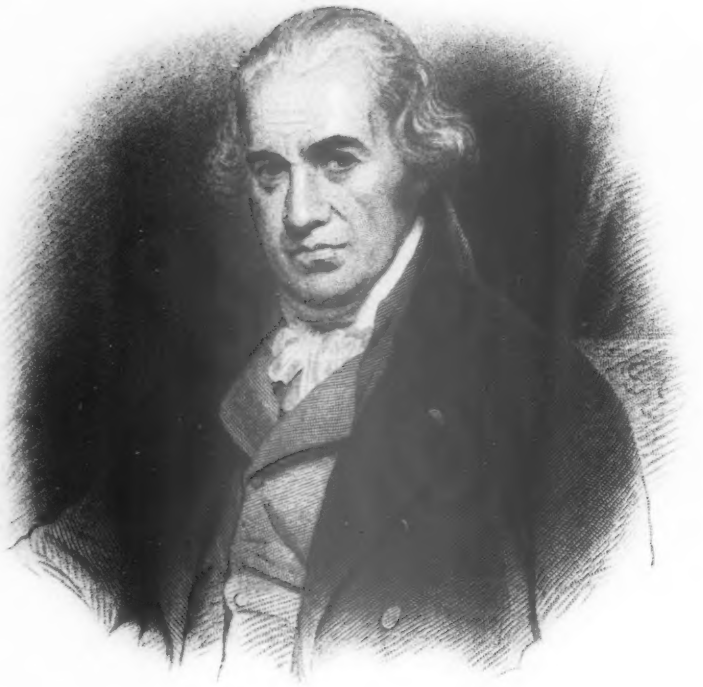
James Watt

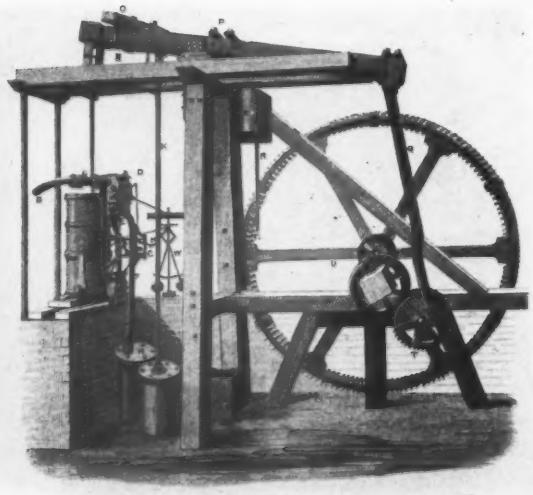
The Inventor of the Modern Condensing Steam Engine, and Creator of the Science of Mechanical Engineering, Whose Bicentenary Was Celebrated Last Month



Reproduced from engravings in Smiles: "Lives of Boulton and Watt"

". . . I look upon him, considering both the magnitude and the universality of his genius, as perhaps the most extraordinary man that this country ever produced: He never sought display, but was content to work in that quietness and humility, both of spirit and of outward circumstances, in which alone all that is truly great and good was ever done." — William Wordsworth.

Along with many institutions in England and America, M.I.T. held bicentenary exercises on January 20. With Franklin A. Park, '95, presiding, addresses were delivered by President Karl T. Compton, Dr. William F. Durand, and Professor James R. Jack.



Left. *"Old Bess," an engine built by Watt in 1778 or 1779 (he invented his steam engine in 1765 and patented it in 1769), and one of the first to transform reciprocating motion into rotary motion.* Below. *Watt's garret at Heathfield which was his laboratory during the later period of his life, and which is now reassembled in the Science Museum, London*

THE
TECHNOLOGY REVIEW

Vol. 38, No. 5 February, 1936

The Trend of Affairs

Oil's Origin

LONG before petroleum became of economic importance, the question of its origin was hotly debated by chemists and geologists. The first theory to be considered seriously postulated the formation of metallic carbides while the earth was still fluid. These were supposed to remain as such while the igneous rocks solidified; later, sea water seeped down to them through fissures and reacted to produce hydrocarbons and metallic oxides. The manufacture of acetylene gas from calcium carbide is exactly this process; acetylene can be polymerized to petroleum-like products. Although, with small variations, the foregoing theory may well account for the origin of volcanoes, it is inadequate as an explanation of natural petroleum: first, because petroleum contains optically active compounds of a type never produced by inorganic reactions; second, because animal and vegetable residues are often found in it.

Fantastic elaborations of such theories have been proposed: One writer would have a volcano burst out under the sea, the gases or liquids evolved kill all the fish in the vicinity, and the dead fish fall into the hole, to be covered and converted to petroleum by heat and pressure. Practically minded people have distilled fish at high temperatures and pressures and have obtained petroleum-like products. It has generally been assumed that heat and pressure have been essential for such reactions. Until recently, it has generally been assumed also that petroleum, if of organic origin, must have come from the fatty constituents of animals or plants, since the hydrocarbons of petroleum stand in closer structural relation to the fats than to any other constituents of organisms.

At the Organic Chemistry Symposium of the American Chemical Society recently held at Rochester, N. Y., Dr. Benjamin T. Brooks discussed new and important material on the origin of petroleum. He pointed out that the temperature of the deepest wells rarely exceeds 150 degrees F. and that the hydrostatic pressures in the oil beds are less than those employed in some commercial chemical syntheses. Oil deposits are estimated to be 150,000,000 or more years old — perhaps even such a complex reaction as the production of petroleum from green plants could occur at moderate temperatures and pressures, when given such a long time!

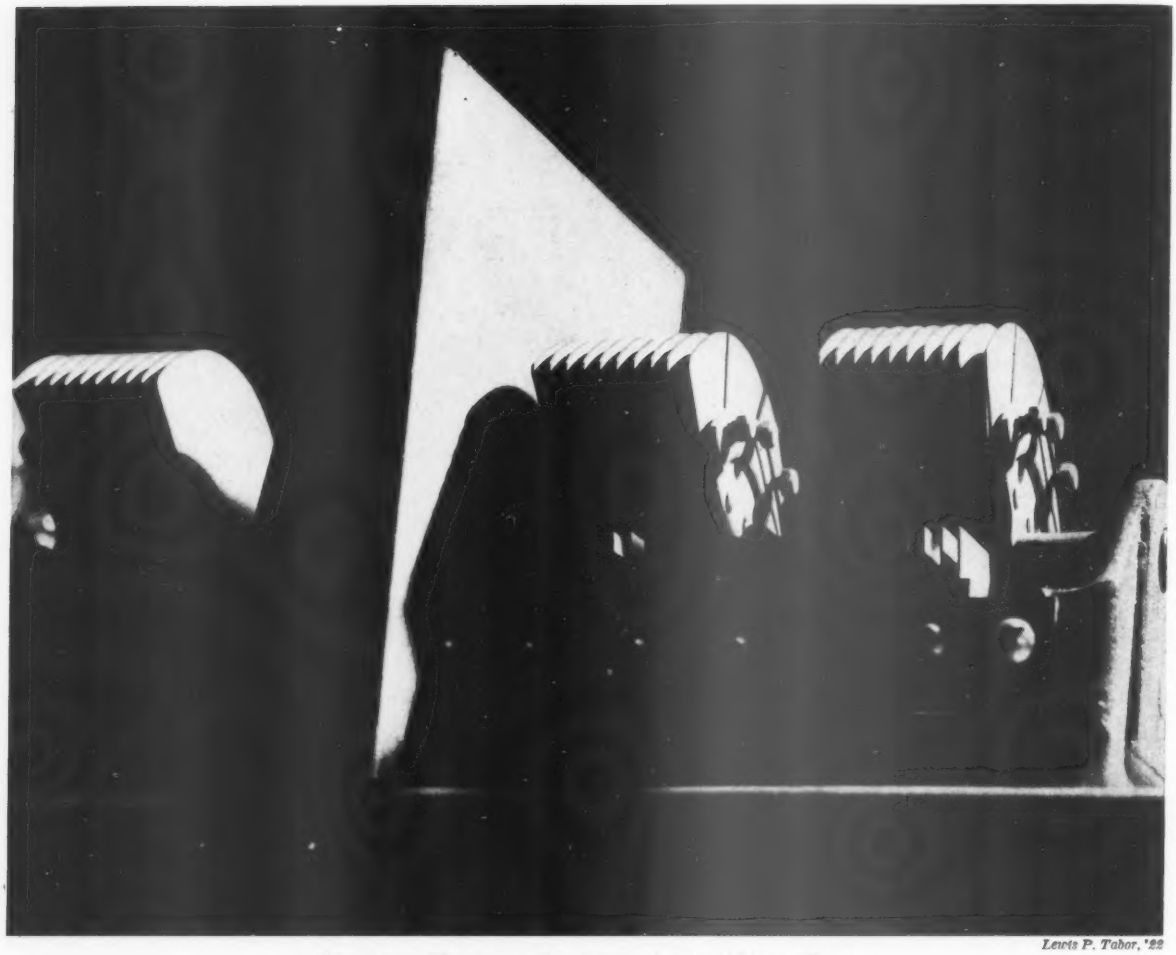
Recently, colored compounds known as porphyrins, closely related to chlorophyll (the green coloring matter of leaves), have been isolated from petroleum. This proves that petroleum is at least partly of plant origin; further, since porphyrins are very easily decomposed by heat it is improbable that petroleum has been hotter than 400 degrees F. at any state of its history.

Dr. Brooks discussed also the question of further spontaneous changes in the nature of petroleum under its present conditions of temperature and pressure — that is to say, whether or not the constituents of petroleum are in chemical equilibrium. From consideration of the absence of free hydrogen in petroleum and natural gas and from the relative amounts of aromatic hydrocarbons at different depths, Dr. Brooks concluded that petroleum is not an equilibrium mixture.

OTHER views, discussions, and conclusions noted by The Review observer at the Organic Symposium:

¶ Professor Marston F. Bogert of Columbia pointed out that the pigments of flowers and vegetables, vitamin A, and isoprene (the structural unit of natural rubber) are structurally related.

¶ Professor L. F. Fieser of Harvard reported relationships between morphine, the toad poisons, saponins, and hydrocarbons having a tendency to produce cancer, on the basis of the phenanthrene unit.



Lewis P. Tabor, '22

Capacitance. The photographer discovers beauty within a radio set

¶ Professor Vincent du Vigneaud outlined the present status of vitamin and hormone chemistry in an exceptionally clear and interesting manner. It appears possible that powerful preparations of hormones, capable of controlling almost completely the rate and extent of development of adult characteristics and sexual activity of men and animals, may be obtained synthetically, starting from wool fat. The possible effect on our economic and social structure of the large-scale production of such drugs is the subject of much speculation by chemists.

¶ Professor Lydon F. Small advanced the interesting point that the alkaloids, so useful in medicine (quinine, for example), are unwanted by-products of the plants which grow them and are, for that reason, stored away in the bark or husks as quickly as possible. Dr. Small went on to show that some of the simpler alkaloids could be synthesized from very simple compounds in the laboratory under conditions sufficiently mild as to be possible in living plants.

¶ President Conant, Harvard — introduced as "Dr. Conant, a member of the Division of Organic Chemistry in good standing" — discussed experimental work on the heats of hydrogenation of unsaturated hydrocarbons, done in collaboration with Professor Kistiakowsky. Dr. Conant demonstrated in a very clear and convincing manner the great utility of thermochemical principles.

Extrapolating Existence

MATERIALISTS and vitalists, alike, probably will find in the virus protein, which Dr. W. M. Stanley of the Rockefeller Institute described to the American Association for the Advancement of Science in St. Louis last month, argument for their respective theories about the origin of life. Alive and, yet, not alive according to usual criteria, the protein which was extracted from tobacco virus is merely a minute crystal; yet it reproduces itself, and, what is more important, it causes disease in plants exactly as does the mosaic virus. Seemingly, it may be a link between living and nonliving matter and, as such, may be of pronounced philosophical significance, in so far as it may be used to substantiate the theories of those who believe that life can be produced independently of antecedent life.

These abiogenists will see in it possible substantiation for the assumed origin of living matter through molecular combinations under fortuitously satisfactory condi-

tions in some far removed geological period, or they may use it to force vitalists to push back still farther in time the supposed arrival of life on this planet.

Unfortunately for controversialists who seek tangible evidence, filtering discloses that in size the virus protein is less than a molecule of albumen. Its virulent activity is stopped, as living things are killed, by excess of acidity or of alkalinity. It is digested by pepsin. It is killed or terminated by a temperature of 201 degrees F. Recrystallized again and again, it preserves physical, chemical, and biological properties unchanged. On this last score, it appears to be an inanimate chemical compound. The question which Dr. Stanley hopes to answer next is whether virus activity is also a property of the protein molecule and not necessarily only of a living thing. Vitalists will be slow to concede without clear evidence that activity, even so malign and apparently nonvolitional as that of a virus, can be an attribute of nonliving matter.

The limits of life had been extended in the other direction, theoretically at least, earlier in the month by Dr. Alexis Carrel. In a lay address at the New York Academy of Medicine, the biologist who has kept a chicken heart alive for 24 years at the Rockefeller Institute linked the following: revivification of dessicated animals such as the arthropods, *Tardigrada;* improvement of rejunevating medical technique through such apparatus as the artificial heart and lung invented by Colonel Charles A. Lindbergh; analysis of the conditions responsible for the aging of tissues; search for the physiological factors which determine longevity. Through these four means, he held that death may be deferred; it cannot be conquered.

The remote possibility of placing men in storage for long periods of time, with animation suspended, and of bringing them back to normal existence at intervals offers interesting speculation to the social historian. If the retentiveness of memory were maintained during the intervals of storage and if individuals of keen mental powers were selected for this partial immortality, useful criticism of stages of culture in the light of the remote past might be had from them — not to speak of the solving of historic enigmas. It does not require the imagination of a Wells to conceive the popular excitement in the world state of 2436 A.D., when, through television and brain-wave radio transmission, the recollections of the man who has been asleep since 2136 A.D. are transmitted from Swakopmund throughout civilization.

Future developments from the findings of Dr. Stanley and Dr. Carrel may offer the implementation for man's aiding the process of his own evolution, thus providing an answer to a problem which man should consider, as Dr. John C. Merriam told the Association in St. Louis.

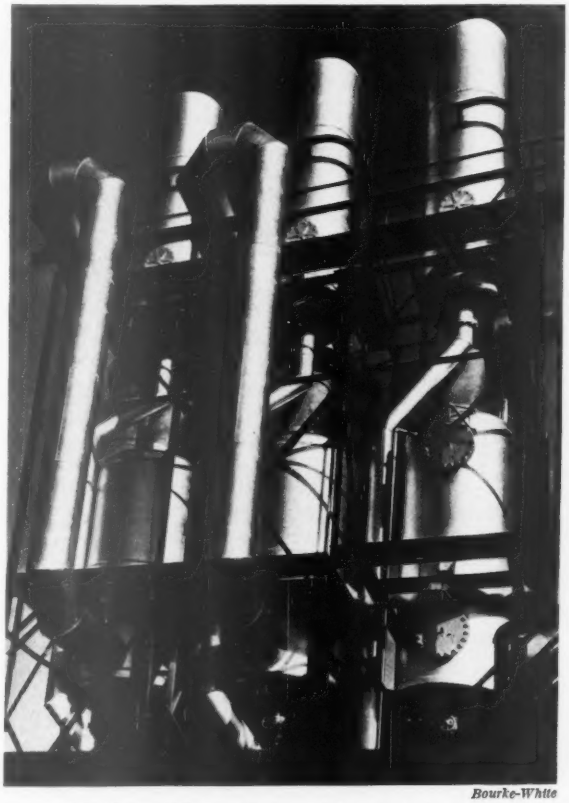
Help for Narcoleptics — and Professors

'Tis the voice of the sluggard, I hear him complain;
"You've waked me too soon, I must slumber again."
— Isaac Watts

TO professors whose students fall asleep in class, the now prevailing medical opinion is very consoling: The fault is not with the lectures, but with the central nervous systems of the students. The students are suffering, not from boredom, but from narcolepsy. They have an ailment which makes them subject to fits of drowsiness. The ailment ought not to be treated by the various psychological tricks which have been well known to professors, rhetoricians, politicians, and others from time immemorial, for it is not psychological; it is physiological and can be rectified by means of medicine.

A recent paper in the *Journal* of the American Medical Association reports experiments on a new synthetic drug, benzedrine, which have been carried out at the Boston City Hospital and the Harvard Medical School. The new drug has been found, in nine cases, to give complete relief to persons who fell asleep at least three times a day. Seven of the cases were students, one was a housewife, and one an office worker. One of the students was a girl who had had to give up her attendance at college because she couldn't prevent herself from falling asleep in class. Three of the students, like giggling schoolgirls, suffered from a momentary generalized weakness whenever they laughed. The circumstance must have given their professors an entirely false notion of the efficacy of professorial humor. However, benzedrine has cured the students, and the professors, we hope, are wiser, in consequence.

Benzedrine has been found to be about three times as effective in preventing attacks of sleep as ephedrine which, heretofore, has been used for this purpose. It also gives a virtually complete relief from cataplexy, which is a state of muscular rigidity produced by sudden shock or fear.



Bourke-White

Distillation. The architecture of the chemical engineer

New solar heater, designed by Charles G. Abbot, '94 (left), Secretary of the Smithsonian Institution, and described as "the most efficient apparatus so far developed by man for the direct conversion of the rays of the sun into useful mechanical energy"

Benzedrine is a derivative of ephedrine; specifically, it is racemic desoxy-nor-ephedrine. By making slight changes in the molecule of ephedrine, chemists have been able to alter and improve its pharmacological properties. Ephedrine is also an interesting drug. Although it has been used for only a few years in occidental medicine, it has already established a definite place for itself. In general, it has the same effect as adrenaline, which has to be injected hypodermically, but ephedrine has the advantage that it may be taken through the mouth. It is useful for asthma and hay fever. The plant which contains the drug has, for centuries, been included in the *materia medica* of the Chinese, who were well aware of its applications and usefulness. Chemists, seeing that the Chinese plant had real medicinal value, isolated the active principle from it, determined the arrangement of the atoms within its molecule, and developed methods of synthesizing it from cheaper and more abundant materials. Synthetic ephedrine is now on the American market, as is benzedrine, a drug which is not known to occur in nature and is better than ephedrine in certain respects.

Science on Display

EARLY this year, with a roll of news drums and a considerable scientific fanfare, the New York Museum of Science and Industry will throw open the doors of its new home in the Forum of Rockefeller Center. The event will mark the coming of age of this important adjunct to New York life and, incidentally, will at last provide a use for a space that has been plaguing the management of the Center.

The Forum, designed originally as a tiered restaurant with a central well for night-club-like performances, has never seen a floor show, for it was found that the tiers were so arranged that no table sitter could view the show. Hence, except for a sporadic exhibition or two, the Forum has remained a mausoleum of embalmed hopes for whoopee in Rockefeller Center. Where the Trixie Friganzas of a new age were to have tripped it lightly, a full-size model of the *DeWitt Clinton* will huff and chuff; walls that were to have echoed to the pop of champagne corks will reflect, instead, the crackling discharges of Leyden jars; decorations that might have consisted of aluminum foil and glass will consist, instead, of sections of cams, gears, and bearings.

Ideally situated for such a museum, the new space is also ideally laid out. Convenient stairs lead comfortably from tier to tier, and the tiers themselves are well arranged to permit an orderly display of the material now in the collection. Moreover, a very good mezzanine will permit adequate presentation of a new feature of museum policy — the housing of temporary exhibitions contributed by industries which are "sold" on science — calculated to bring to the nonvoyaging New Yorker an appreciation of the fact that things are happening in Schenectady, Akron, Pittsburgh, Madison, Detroit, Rochester, and other outlandish points.

The first of these exhibitions, concomitant with the opening, will be based on the things seen on the recent tour of laboratories run by the National Research Council (see The Review for December, 1935, page 90). Others now being planned will deal with shelter, transportation, and communication. It is hoped, on this mezzanine, to keep the public currently informed, while the rest of the museum will educate those uninitiated in the past of the industries and the sciences.

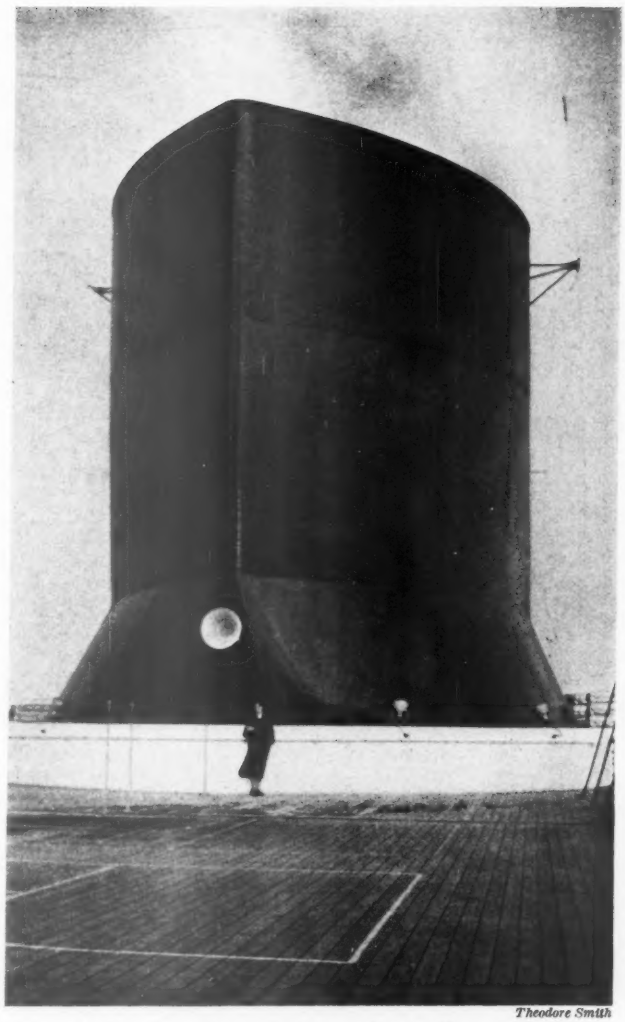
Although overshadowed somewhat in the public eye by the larger museums of the Franklin Institute in Philadelphia, opened in 1934 as a result largely of public

Walter S. Meyers

"In the Web" — a photograph from Brooklyn Bridge

subscription, and the Julius Rosenwald in Chicago, occupying the reconstructed Fine Arts Building of World's Fair fame, the New York Museum is the oldest, planned science museum of full scope in this country. There are, of course, other older collections, including those of the Smithsonian Institution and of the Bell Telephone Company.

The New York Museum has had a somewhat unsteady history. It was first suggested in 1912 at a meeting of the American Association of Museums. In 1914 it was incorporated under the name of the Museum of the Peaceful Arts — the incorporators including such men as Schiff, Tesla, Gary, Towne, Edison, Vail, Peary, and Huntington. In 1924, Henry R. Towne, the lock manufacturer, left a considerable bequest contingent upon the establishment of a satisfactory institution. This resulted in a trip to Europe for Charles T. Gwynne, during which moving pictures were taken in the four principal foreign museums. These pictures and the Gwynne report have served as the bible of all the industrial museums here. In 1926, the Museum took demonstration space in the *Scientific American* Building and, from 1927 to 1929, spent its funds in the acquisition of exhibits and the creation of a favorable public opinion. By 1930, larger quarters were required and the present name was adopted as the Museum moved to the Daily News building. Here, in one twelfth the space of the famed Deutsches Museum, the New York show entertained 55% as many visitors as that organization in the year 1932 to 1933. Meanwhile, with increasing interest and despite liberal donations by the Carnegie Corporation and the New York Foundation, funds were running low, and in 1933 the trustees had to report that there was money enough for only one more year. At the same time, a more central location appealing to a better class of visitors was sadly needed. Today, with more money and with a new board of trustees which includes Frank B. Jewett, '03, as President, and Gerard Swope, '95, the Museum seems to be on the march.



Theodore Smith

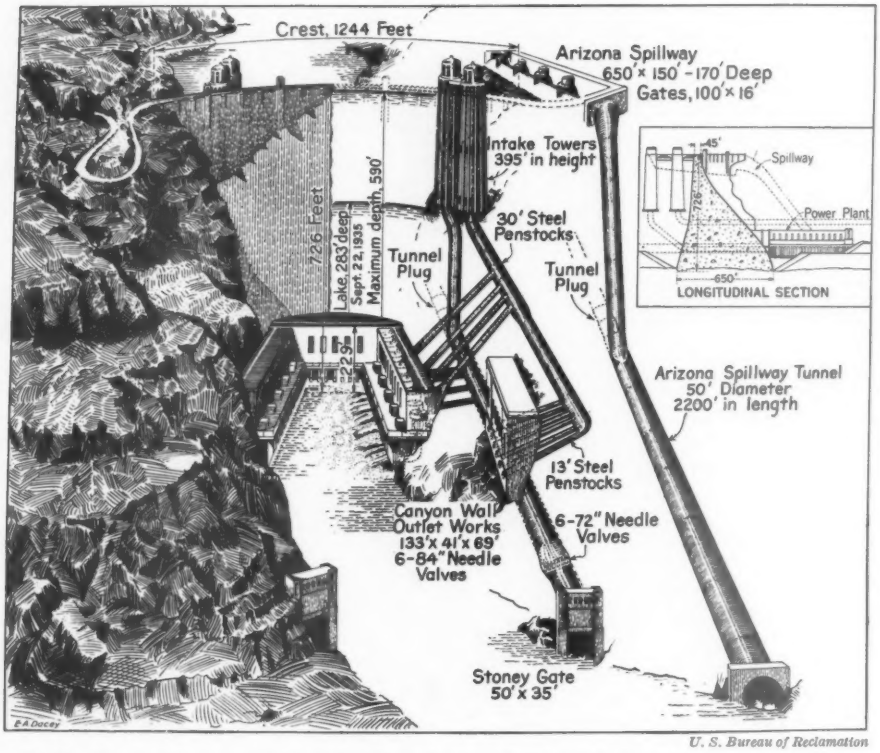
Scale — one of the streamline funnels of the Normandie

All this while, the Museum has had at its disposal the offer from the city of a considerable plot of land in Jerome Park for a new building. However, in some contrast to the policies of the Philadelphia and Chicago museums, the New York directors have held it better first to have a museum and only secondly to have a building.

The idea of the science museum is still in its infancy here. In Europe, of course, it is very old. The Musée des Arts et Metiers in Paris really began in 1782, when de Vaucanson left his tools to such a museum, and was actively prosecuted when Descartes became interested in 1799. Today a stuffy set of medieval buildings house, in no very brilliant style, a large and often exciting collection, including original Jacquard looms, original apparatus from the laboratory of Lavoisier, original work by Daguerre. This museum is planned for those who know something about what they are studying. It has amphitheaters for lectures and tracks to carry material to these amphitheaters. Very little explanatory material exists for the casual passer-by. Americans who have rather generally criticized this exhibition are prone to forget that French museums in general are planned for the intelligentsia; they forget that the Carnavalet, for example, would not be very exciting to one who had not already been excited by French history.

Next chronologically in Europe is the Science Museum in South Kensington, London, built, like the Rosenwald, on the exhibits from an exposition — in this case that of the Crystal Palace. Opened in 1857, it occupied a new building in 1924. The exhibitions here are better for the casual visitor than those at Paris, as they are well placarded and many are capable of motion. Moreover, the collection of originals is noteworthy, including materials from Watt, Arkwright, Stephenson, Maudsley, Bessemer, and scientists such as Babbage, Herschel, and Kelvin.

It is in the Deutsches Museum at Munich, however, that Americans have found their principal stimulus. This museum, the greatest of its kind in the world, is the work of one man, Dr. Oskar Von Miller, who proposed the original plan in 1903, lived to round out the collection,



U. S. Bureau of Reclamation

Boulder Dam and its appurtenant works. An explanatory drawing with the Arizona wall cut away to reveal the intake towers, spillway, penstock pipe, and outlet works

the erection of a reinforced concrete group of buildings on the Isar in 1913, the move to the new buildings after the War, in 1922, and the formal opening on May 6, 1925, celebrating his 80th birthday.

The Deutsches Museum is not only large; it is built on a different thesis from those of Paris or London — the thesis that the masses need education in the processes by which they are able to live today, and that this education must start with primitive efforts in a given field and carry through the salient steps, and only those, down to date. Realism, dioramas, color, sound, motion, are employed to the fullest. (The richest American demonstration of the last-mentioned phases of the technique was given in the Hall of Science of the Century of Progress.) Dr. Miller was a unique collector: With equal ease, he wangled a $50,000 steamship model from the Kaiser and a planetarium from the Zeiss Company. Moreover, he kept himself untrammeled and accepted no restrictions on the collection. Thus, while Paris has had to keep and exhibit every donation, thereby accumulating a considerable amount of junk, Munich is free to edit. The editing has, however, not been quite so free as is needed for a truly popular museum, largely because of the Teutonic enthusiasm of a group of specialists who have arranged the collection. The Munich museum tends to be a little bewildering. From this point of view, the simpler and new Technische Museum of Vienna, opened in 1918, is an improvement.

In America, the Miller influence has been widely reflected through Dr. Charles R. Richards, '85, who has been the outstanding American authority. Departures from the Miller technique in this country are largely in the greater emphasis on complicated modern improvements — at some loss to the teaching of fundamentals. This, however, is not Dr. Richards' fault.

The chief problems confronting all American museums are those raised by corporations and children. The corporations must, in the last analysis, supply all the materials, and few have the prescience to realize that the best publicity is the least obtrusive. Sales departments have their say, and it has been very hard for the museums to keep their shelves free from specific demonstrations closely keyed to individual companies. Children offer difficulties because they are too young to understand many of the demonstrations but are so thrilled by motion that they are likely to be in the way.

Mass education is such a fetish in America that it is natural that the museums should follow this same principle. For this purpose, originals are unnecessary, perhaps even undesirable as being too valuable. Moreover, there is a vast accumulation of material too special in interest to have a place in a museum which sets out to educate those ignorant of the whole field of science and industry. There is, therefore, room for another more technical type of museum to whose quiet halls the studious might repair for study or even for intellectual repose. There is little use in letting educationally unwashed hands paw over the original *Rocket*. Yet, the student of transportation might feel a religious awe in the presence of the original that no reproduction could create synthetically.

In this connection it is interesting to note that the original charter of Technology provided for the establishment of a museum in conjunction with the Institute. It was recently decided to use the more than two-and-one-half miles of corridors in the Technology buildings as exhibition space for the Institute's collection of historic apparatus, models of important engineering structures, and new scientific devices. Splendid displays of economic minerals and of ceramic products are now completed, and others will be added as funds and time permit. The Institute's Naval Museum is steadily growing, both in fame and size. Taken together, these exhibits will provide for Metropolitan Boston a science museum designedly less theatrical than many of the larger museums, devoted to the technically discerning.

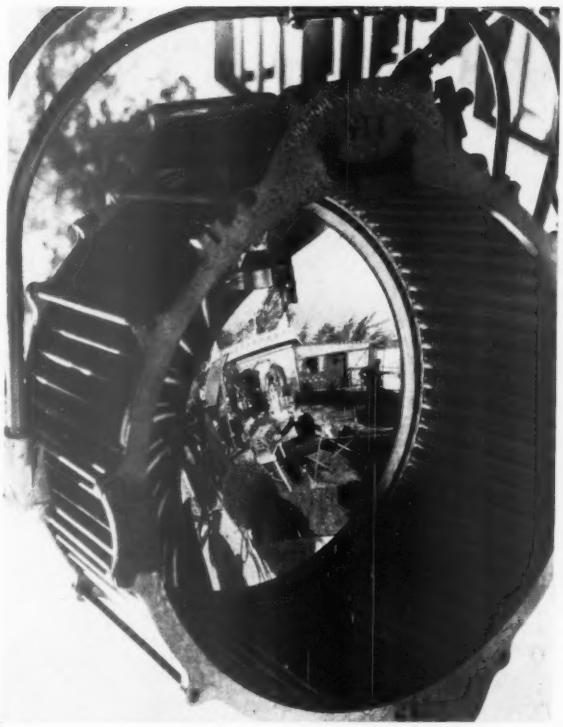
The more popular museums, however, have an important place in the national life. Chicago, Philadelphia, New York might well have collections of general interest; Pittsburgh and Detroit, of more special interest. To the New York Museum of Science and Industry, The Review wishes a pleasant housewarming and a long and successful occupancy of its place in Manhattan life.

Wooziness

NOW that passenger transport planes are flying regularly at altitudes up to 12,000 feet, where the air resistance permits high speeds and a marked saving of fuel, the need for information on the physiological effects of reduced atmospheric pressure and oxygen content of the air becomes a matter of immediate importance. While there is considerable medical information on the effects of pressure in general, very little research has been done on the physiological consequences of altitude flying.

Aside from nausea, headaches, prostration, and irritability, which are apparent in varying degrees in persons sensitive to reduced pressure and low oxygen supply, it is known that the spleen reacts immediately with a contraction which forces more of its blood cells into the blood stream to assist in carrying the reduced supply of oxygen to the body tisses. Only a few of the thousands of passengers traveling at high altitudes appear to feel any ill effects. Sensitive individuals, however, may experience earaches and a disturbance of the sinuses.

At 16,000 feet, an altitude reached daily by the meteorological observation planes in various parts of the country, the air pressure is approximately 50% less than at sea level. At this height many pilots find it necessary to resort to their oxygen, although a few experience no great discomfort. However, any effort, mental or physical, is likely to produce distress: Routine movements in operating a plane become extremely exhausting, reaction times increase, and even the mental effort exerted in looking at an instrument or in making simple calculations or decisions becomes painful. These effects are definitely related to oxygen deficiency, and alertness is restored by enrichment of the air supply. The first signs of this condition, generally described by pilots as "wooziness," is extreme lethargy and inability to concentrate on normal tasks.

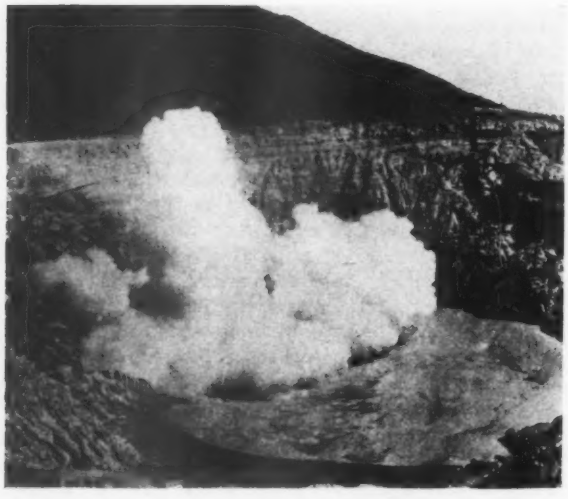


The camera captures, in a searchlight, the reflection of a motion-picture set (the searchlight is shown upside down, of course)

Ralph F. Peo, Vice-President of the Houde Engineering Corporation, and his Houdaille-Carrier air-conditioned automobile after a 12,000-mile test run. Complete year-round air conditioning is now available for busses, and it can be applied to taxicabs and private cars

The effects of pressure changes on the body may be far more complex than is realized in the light of present knowledge. In deep-sea diving, for instance, a rapid decrease in pressure, which causes what is known as the bends or caisson disease, is very dangerous. This condition is due to the fact that under the influence of increased pressure, nitrogen passes from the blood stream into the tissues. Time must be allowed for the dissipation of this nitrogen or the results are serious. For this reason, divers working at depths of 50 feet or more must ascend to the surface very slowly, stopping frequently to give the body time to readjust itself to the gradually decreasing pressure. The ascent from a depth of 100 feet may require as much as an hour.

While the diver goes from normal atmospheric pressure to pressures far greater than the body is ordinarily called upon to stand, the flyer reverses the process by going from normal to reduced pressures. It would be interesting to know what effect, if any, the rapid changes in pressure encountered in flight have on pilots and passengers — whether the swift descent from rarefied atmosphere to normal produces changes of which we are not yet aware. The diver adjusts himself very



slowly to pressure changes, whereas the flyer may descend thousands of feet from low to normal pressure in a few minutes.

Experience indicates that duration of exposure to rarefied atmosphere and low oxygen content may be an extremely important factor in physiological effect. During the World War officers of the German Zeppelins, which cruised at high altitudes and remained in hiding above the clouds for many hours at a time, reported that after a considerable period under such conditions the crews, long accustomed to flying, began to suffer considerable discomfort. Pilots remaining at high altitudes for a long time experienced the same effects. It seems highly desirable, therefore, that this important aspect of the problem be thoroughly investigated.

Professor Yandell Henderson of Yale University, an authority on asphyxia, suggests that the physiological effects of altitudes higher than 10,000 feet should be investigated. His own studies of the effects of pressure changes on the human body show that there is a wide variation in individual toleration of oxygen deficiency. Whether pilots flying regularly at high altitudes will gradually develop a tolerance, which many appear to do, remains a question to be answered by careful study.

Although the average person apparently feels no discomfort in flight up to 12,000 feet, Dr. Henderson suggests that, from that altitude upward to 20,000 feet, oxygen might be necessary as a precautionary measure. For passenger flights above (*Concluded on page 200*)

WHEN POAS LET GO

Despite quakings beneath him and rumblings in the air about him, Edward T. Owens, engineer of Jacksonville, Fla., outstayed his guide and companions to catch these views of the 1916 eruption of a Costa Rican volcano. The crater is at an altitude of 8,895 feet and is usually covered by clouds, except for a few minutes now and then in the early morning. The sulphureous, green lake is perhaps 900 feet below the rim and is approximately a mile in diameter.

The four pictures were taken about four seconds apart. Mr. Owens estimates that the lava and steam in the first had risen to 200 feet above the lake; in the second, to 500 feet; in the third, to 1,000 feet; in the fourth, possibly to 2,000 feet. Although taken 20 years ago, these rare pictures are now reproduced for the first time

Philosophers' Stone: 1936 Model

Which Might Also Be Called The Alkahest

By Philip M. Morse

IN the delightful little book entitled "Alchemy," written by the Rev. J. E. Mercer, sometime Bishop of Tasmania, we find the following excerpt:

> Van Helmont's belief in the discovery of the Universal Solvent, called by Paracelus the Alkahest, affords another striking instance of over-credulity. . . . There is no telling how long the Alkahest might not have maintained its reputation, had not a critic pointed out the simple reflection that if the solvent really existed, it could not be stored or used; for it would dissolve the vessels in which it was contained!

We regret having to consider the Rev. Mercer's attitude as smacking of over-*in*credulity, but during the last five years physicists have discovered a material which, in a sense, *is* the Alkahest. And curiously enough, it has also the properties of the famed Philosophers' Stone! We say this new substance is a universal solvent, *in a sense*, for it does not mix with materials by making them liquid; it simply is able to pass through all materials as air can pass through a sponge. The dilemma expounded above turns out to be, not a proof of the nonexistence of the Alkahest, but a simple statement of the practical difficulties physicists encounter in controlling it.

The material is a gas, of course, since nothing has been found which can compress it to any appreciable density. Only five years ago were molecules of this gas detected; only three years ago did we learn how to produce them in any great quantity. Individual molecules of this curious substance are called neutrons. Stray individuals were detected by Bothe and Becker in 1930. In 1932 Irene Curie and her husband, Frederick Joliot, found out how to produce a few of them. These investigators labeled the particles as unknown radiations, and it was Chadwick, in the same year, who revealed their actual nature. In a paper which reads as though it may become one of the classics of science, he showed that the new radiation consists of particles of mass approximately equal to that of the hydrogen nucleus, but differing from all other atomic nuclei in having no electric charge. For this discovery Chadwick received the 1935 Nobel Prize in physics, and the Curie-Joliots, the Nobel Prize in chemistry. (So *this* is chemistry!)

In the short time since neutrons have been known, their properties and behaviors have been studied intensively by workers of nearly every nationality: The investigators at Cavendish Laboratory have watched individual neutrons play hob with individual nuclei; in 1933, research men at California Institute of Technology discovered methods of producing them in great quantities; Fermi and his associates in Rome showed they would cause transmutations of all varieties of atoms; workers at Columbia University have studied their ability to sneak through solid matter. Every month some new and interesting property is reported; many of the phenomena mentioned in this article have been discovered since last spring.

Neutrons can be produced in many ways. The least complicated source is a piece of beryllium in contact with radium emanation. Beryllium is particularly susceptible to nudges from the alpha-particles given off by the emanation. It absorbs the alpha-particles, breaks down into carbon, giving off neutrons as a by-product. Although the method is quite simple, it is practicable only for producing small quantities of neutrons, as radium emanation is rather hard to get in large quantities. A much more plentiful supply can be obtained by shooting heavy hydrogen atoms at beryllium, with very high velocity. A milliampere current of million-volt, heavy-hydrogen particles falling on beryllium will produce about 10^{12} neutrons per second. Van de Graaff's big six-million volt generator may be able to produce as much as 1,000 times this quantity, or about one microgram of neutron gas an hour.

This seems like an exceedingly small amount of neutron gas for all our efforts, but it is much more than we know what to do with at present, because we have no way of keeping the gas, once we have obtained it. Neutrons, having no electric charge, pay no attention to the cloud of electrons guarding each atom of ordinary matter, and rebound only when they hit the tiny center of the atom, the nucleus. Since the nucleus offers less than one millionth of the obstruction which the cloud of electrons surrounding it does, neutrons are able to slip through matter as solid as iron with no more difficulty than an atom of ordinary matter has in going through a vacuum of one-thousandth atmosphere. Imagine trying to store a gas with nothing less porous than cheesecloth!

As a matter of fact, heavy material is much less efficacious in confining the gas than is very light material, especially one containing many hydrogen atoms. The neutrons, when they are given out by the beryllium, are traveling at a very high rate of speed and must be slowed down before they will consent to stay long in one place. Neutrons bounce off heavy nuclei without loss of energy, but when they strike hydrogen they give up half their energy, on the average. A dozen or so collisions with hydrogen atoms serve to calm them down. The best storage tank which has been devised so far for neutron gas is a small pocket in the center of a very large block of paraffin. The paraffin does not hold the gas in with any marked success; nevertheless, it offers enough resistance to its passage so that a small partial pressure of neutrons, perhaps a billionth of an atmosphere, is built up inside the pocket. Workers at Carnegie Institute of Technology have drilled a hole into such a pocket and have observed a wind of neutron gas

streaming out. They have even measured the velocity and the number of the neutrons in the wind.

Although neutrons can penetrate any substance, we have not been perfectly accurate if we have given the impression that all matter is equally transmissive. Some materials offer a very much greater barrier than others, and this variation in obstructing power seems, at present, to have no rime or reason. For instance, light hydrogen presents nine times the barrier that heavy hydrogen does; cadmium offers 800 times the barrier of tin; gadolinium, 1,000 times the barrier of barium or cerium; mercury, 42 times the barrier of lead. The abnormally large obstructing power of cadmium, gadolinium, and mercury is of no help to us, however, in building a storage tank, for these nuclei do not bounce the neutrons back into the receptacle — they simply swallow them. In fact, they seem to reach out and kidnap neutrons going by at a distance as large as ten or more times the nuclear radius. Cadmium plates with holes in them are used to define beams of neutrons, for few neutrons can get through a thick sheet of cadmium without being swallowed up; but cadmium is a poorer material than paraffin for making storage tanks; it is too greedy.

Nearly any sort of atom can be induced to swallow a neutron once in a while. Since the neutron has no charge, it can sneak up and slip inside a nucleus without being affected by the electric field which keeps other nuclei away. Once having swallowed a neutron, a few atoms (such as cadmium, mercury, light hydrogen, and yttrium) simply digest it, becoming heavier nuclei of the same material. Light hydrogen, for instance, becomes heavy hydrogen. A great majority of nuclei, however, have acute indigestion and break up into nuclei of other chemical elements. This, of course, is transmutation; our modern Alkahest is also the Philosophers' Stone.

Atoms differ considerably in the ease with which they are transmuted by neutrons. Cadmium, gadolinium, and mercury are among the most susceptible, as we have noted previously. At present, with the exception of nickel, investigators have been able to produce transmutations of every element they have tried, and they have tried practically all of them. Why nickel proves so obdurate is not as yet understood.

When nuclei absorb neutrons, they do not transmute immediately, but wait awhile before exploding, as radium nuclei do before they change to radium emanation nuclei. The artificial radioactivity produced by neutrons is not so slow a process as is that of radium or uranium, but it is often slow enough for the induced radioactivity to be measured. The average life of an atom of radio-silver, for instance, is several minutes, and the average life of radio-sodium is nearly a day.

Incidentally, we are just beginning to see the immense importance which radioactive atoms of the common chemical elements can have in science and engineering. They can be used as exceedingly sensitive indicators, for one can detect the presence of only a few atoms of a radioactive substance. To measure the diffusion of chlorine through a steel container one simply mixes a small amount of radio-chlorine with ordinary chlorine, and measures the increase of radioactivity on the outside of the container. If one wishes to follow the circulation of the blood in the human body, one can insert a minute amount of radio-sodium chloride in the blood stream and then measure the radioactivity of different parts of the body. The amount of radio-sodium needed is much too small to do any damage to the body and, in addition, the radioactivity practically disappears in several days. Radium cannot be used for such exploration because it is too expensive to lose, because it is a heavy element which collects in the bones where it cannot easily be removed, and because its radioactivity continues for thousands of years.

You may wonder how investigators can detect such slippery things as neutrons. As a matter of fact, it is possible to count them individually, if they are going fast enough, by amplifying the ionization produced when a neutron breaks a nucleus into pieces. It is also possible to photograph neutron beams in a manner somewhat analogous to the photographing of a beam of light — the induced radioactivity of various materials can be used as a measure of the intensity of the neutron beam which has fallen on the materials. A sheet of silver, for instance, becomes radioactive when neutrons fall upon it, giving up electrons and becoming cadmium. On the average, the silver atom waits several minutes, after absorbing the neutron, before it gives off an electron; so silver can be exposed to a neutron beam and can then be measured for the intensity of its radioactivity. Many other materials can be used as radiographic plates.

The foregoing sketch will perhaps indicate some of the excitement, the bewilderment, and the fun which physicists have been enjoying in research in nuclear physics during the last few years. It is not surprising, in view of the entrancing problems continually presenting themselves and the frequent glimpses of tremendous useful possibilities, that many workers all over the world have taken up the study. Already more than half a dozen men have started research in this line at Technology. When Van de Graaff's great generator at Round Hill is completed, Technology will take its proper place in the forefront of research in nuclear physics.

Wide World

President Compton demonstrates in St. Louis the new radium detector developed by Professor Evans of Technology *(see page 186)*

The Oil-Shed Fallacy

Attacking the Problems of Lubrication by Rational Methods

By Mayo D. Hersey

IT WOULD be a commonplace to say that the latest advances of science and technology are eagerly utilized in every large industrial enterprise, notably in the electrical industries. Most of the technical problems which are recognized as fundamental or recurrent are placed under the direction of professionally qualified men; but not all these problems are customarily so treated, and rarely lubrication.

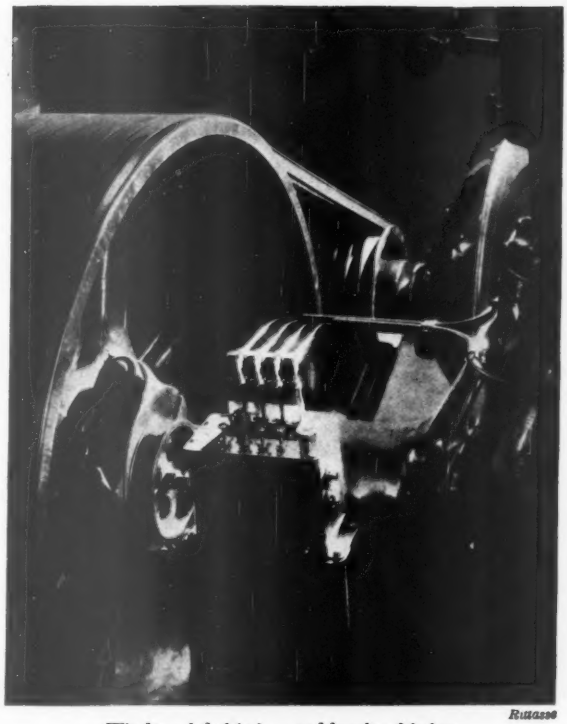
Go to the executives of almost any manufacturing corporation — with a proper introduction — and ask how they are handling their vibration problems, new light-weight alloys, or calculation of electrical constants. In five minutes a number of Ph.D.'s, or electrical and mechanical engineers, will be sitting around the conference table with you.

Inquire about lubrication, however, and the vice-president calls for the chief metallurgist, who doesn't know. "Let's see, now," they ask each other, "who has the key to the oil shed?" After Mike has been sent for and is getting his shirt on, somebody remembers the purchasing agent. But when all has been said and done, it is unanimously agreed that Mike has the only *real dope* in the organization, and that he learned it from the labels on the oil barrels.

Isn't there a fallacy here — a fallacy in the organization chart? Why call upon doctors of science to study the shearing stresses in steel shafting, leaving the shearing stresses in the oil film to the doctors of janitorial service? Why the mahogany conference table for structural analysis and the tin oil shed for lubrication?

Just what is known to date about these shearing stresses in the oil film? How far has our knowledge of the mechanics of lubrication progressed? An attempt was made to answer these questions in a recent series of lectures at the Institute. Certain principles have been established by basic theoretical reasoning, and other facts have been determined by a wide variety of experiments; these principles and facts have been applied with great advantage in the design and operation of machinery.

There remains, nevertheless, a wide gap between the mechanical engineers in each country who are attacking the problems of lubrication by rational methods, and those who work by rule of thumb. In defense of the latter groups, it may be said that many of the problems confronting them each day are more complex than any thus far solved by scientific research methods. We shall consider what might be done to close the gap, after first reviewing some of the principles and facts which have already been discovered and applied in connection with the mechanics of lubrication.



Ritzaus

Windage, belt friction, and bearing friction

***Measuring** the starting friction of a mine car with diaphragm type dynamometer and slow-motion screw*

Principle of the Converging Film

Underlying the mechanics of lubrication we find the principle of the oil wedge, or converging film, due to Osborne Reynolds. The lubricant adheres to both the moving and the stationary surface; if the inclination is such that the lubricant is being dragged into a narrower and narrower space, a true fluid pressure is developed. This pressure supports the load, floats the journal or other moving part, and prevents metallic contact. Consequently such inclination is desirable, and the designer must endeavor to provide for it.

The action is in some respects analogous to that of an airplane taking off from the ground. Reynolds' principle, when formulated mathematically, leads to the hydrodynamic theory of lubrication. By means of this theory it is possible to calculate the film thickness, film pressure, and load capacity of a bearing when the conditions are stated in a simple and definite form.

Rolling friction separated from bearing and flange friction. Kinetic tests using rigid lead cylinder of known moment of inertia

Friction Calculations

The frictional resistance and power consumed in a bearing may be calculated very easily if the shearing stresses at the moving surface are known. These may be found from Newton's law of viscosity, provided, as before, that the problem is sufficiently idealized or simplified. Newton's law states that the shearing stress at any point in a fluid is directly proportional to the rate of shear. In the case of a lubricating film, the rate of shear may be taken as equal to the velocity gradient. The constant of proportionality in Newton's law is called the *viscosity* of the fluid.

For example, suppose it were required to calculate the friction loss in the bearings of a grinding machine, running at a speed of $N=1200$ revolutions per minute, and lubricated with a light oil whose viscosity, Z, at the operating temperature, will be assumed equal to 30 centipoises, or 4.4×10^{-6} pound seconds per square inch. The length of each bearing is $L=6$ inches; diameter of journal, $D=3$ inches; and clearance, or difference between diameters of journal and bearing, one part per thousand. The frictional resistance F in each bearing, i.e., the equivalent tangential force at the surface of the journal, is equal to the shearing stress multiplied by the area on which it acts. The surface speed is equal to 20 revolutions per second multiplied by a circumference of 9.4 inches, or we may say $v=188$ inches per second. The film thickness, h, may be assumed uniform if the bearings are not too heavily loaded, and is therefore equal to half the total clearance, or 0.0015 inch. The velocity gradient, then, is given by $v/h=1.25\times10^5$ radians per second, or reciprocal seconds. Hence if the lubricant is one that follows Newton's law, the shearing stress will be the product of 4.4×10^{-6} into 1.25×10^5, or 0.55 pound per square inch. In each bearing this acts upon an area of 6×9.4 or 56.4 square inches, from which $F=56.4\times0.55$ or about 31 pounds. The work done against friction in foot pounds per revolution is 31×9.4 divided by 12, hence the power loss per bearing is 24.3 foot pounds multiplied by 20 revolutions per second, or for the whole machine, $24.3\times20\times2$ divided by 550, which is approximately one-and-three-quarters horse power. The coefficient of friction for a load of $W=720$ pounds on each bearing would be $F/W=31/720=0.043$.

Mathematical Complications

The foregoing load, $P=W/LD=720/18$ or 40 pounds per square inch of projected area, may be considered relatively light for the speed and clearance given, thus justifying the assumption of a nearly uniform film thickness around the bearing. Nevertheless, in most applications it is necessary to recognize the film thickness as a variable quantity, and it is here that the complications begin. Another complicating factor is the geometrical shape of the bearing. Full (360°) bearings are found in reciprocating engines, but in railway-car bearings and most of the larger types of industrial machinery partial bearings are more common, with contact arcs ranging from 90 to 180 degrees. Length-diameter ratios as low as one half are met in engine bearings and as high as three or four in line shafting.

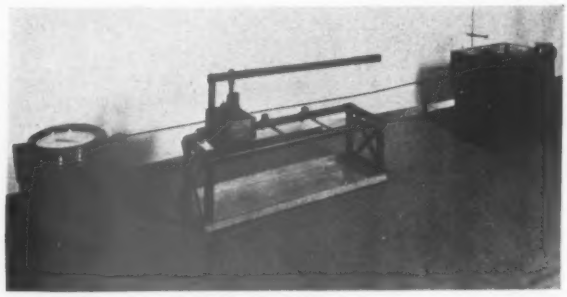
Reasonably complete mathematical solutions have thus far been worked out only for about five special types of bearings: (1) the full journal bearing of infinite length, operating under a load-per-unit of projected area which is relatively small compared to the absolute supply pressure in the lubricant; (2) partial bearings of infinite width; (3) plane surfaces of finite width as applied to thrust bearings; (4) partial bearings of finite width and optimum design; and (5) centrally loaded partial bearings of finite width and 120-degree arc. In most cases the lubricant is assumed to be of a uniform viscosity; in every case the load is assumed to remain constant in magnitude and direction; and the surfaces are assumed rigid and geometrically perfect. Solutions are conspicuously lacking for the full journal bearing of finite length with heavy or fluctuating loads, although they are very much needed to replace the element of guesswork in present-day engine design.

In its mathematical character, the hydrodynamic theory of lubrication is comparable with, and analogous to, the theory of elasticity, but has not yet covered so much ground in relation to its potential applications.

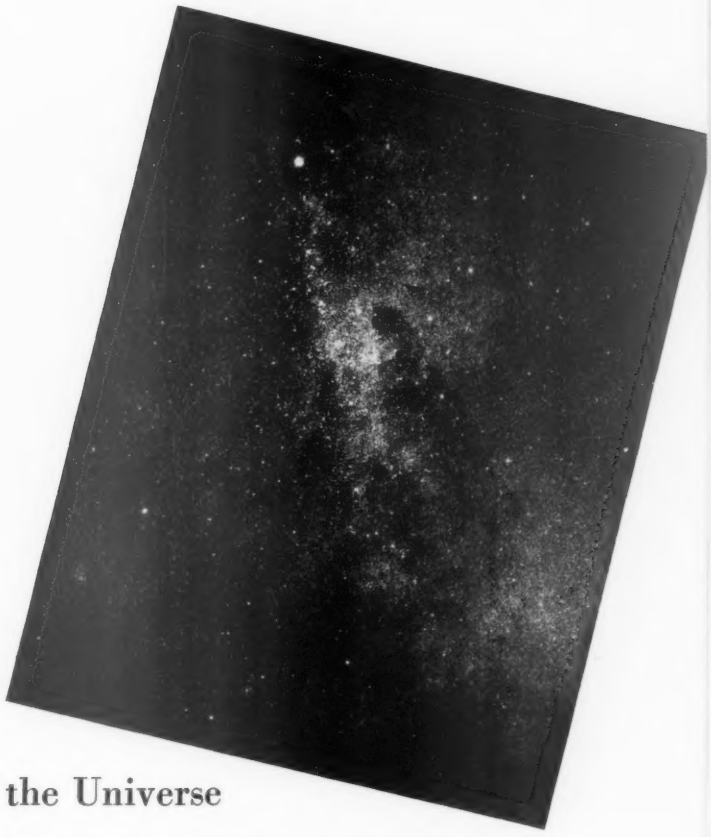
Model Experiments and Dimensional Theory

Because of the foregoing complications — side leakage, for example, in bearings of finite length — the hydrodynamic theory has been supplemented by experimental work of every description, including some very interesting experiments on models. Dr. Albert Kingsbury has integrated the differential equations for thrust bearings and partial journal bearings with the aid of an electrical analogy. Another type of model experiment is made possible by the principle of dynamical similarity.

Two journal bearings are (*Continued on page 192*)



Physical properties of lubricants. Some of the A.S.M.E. high pressure apparatus now at Brown University



The Depths of the Universe

Four exceptionally fine star-field photographs made by Lewis P. Tabor, '22, at Roslyn House Observatory, Wynnewood, Penna. Owned and directed by Gustavus Wynne Cook, Roslyn House is probably the best equipped amateur observatory in the world.

Above, left. *Star field in Cygnus. Bright star at top, a Cygni (Deneb). At left of Deneb, the North America Nebula. At bottom of print, the small nebula at the left of the center is the Network Nebula, and the one in the center is the Filamentary Nebula. Exposure seven hours.* **Above, right.** *Star cloud southwest of γ Cygni, γ Cygni being the bright star about one inch from the left and three-quarters inch from the top. The cluster about one-half inch from the left and three-quarters inch from the bottom is N.G.C. 6940. Exposure three hours, 12 minutes.* **Below, left.** *Star field including the Great Nebula in Andromeda, M-31. Exposure eight hours, 30 minutes.* **Below, right.** *Star field in Cygnus, Lacerta, and Cepheus, interesting because of the dark markings, believed to be due to obscuring matter between us and the star cloud. Exposure four hours, 36 minutes.*

In exposing for these pictures it was necessary to bend the glass plates to bring the edges into focus, and each corner of the plate was focused separately. Imperial Eclipse plates were used

For Sharpening Your Wits

By Request — A Second Collection of Enigmas

By P. J. Rulon

ONCE upon a time there was a man who had two bars of iron. Each was about an inch in diameter and a couple of feet long. They looked exactly alike; but they weren't — one of them was magnetized and the other was not. The man had only these two bars of iron. Perhaps he was out in the woods, 50 miles from civilization, or maybe he was naked, in an Indian canoe without paddles, a thousand miles from land. In any case, his only possession besides these two iron bars was an insistent curiosity to know which of them was magnetized.

A month or so ago, a graduate student at the Institute heard of this man's predicament and, at the end of several minutes, offered his sincerest condolences for the man's plight, but proposed no procedure by which the inquirer might differentiate between the two bars.

This is the way people ordinarily react when they hear of the two gentlemen who got shipwrecked near a bell buoy. One dark night these two men started to row from the mainland to an island some distance offshore in a fairly heavy sea. To keep from getting lost, they followed the course taken by the steamers which served the island. This course was marked by bell buoys near which the steamers always passed. As one big ship went by, the wash upset the rowboat. Fortunately, the men were able to reach and cling to one of the buoys. When the next steamer went by, farther away than usual, they shouted themselves hoarse, trying to attract attention, but without success. Another steamer passed, this time very close to them, but they found themselves too hoarse to shout loud enough to be heard. The problem is: What should they have done to attract the attention of the steamboat crew?

For such enigmas there seems to be no definite method of solution. The attacker simply marshals all the facts he can command and sees whether or not he can put them together and evolve a successful proposal. Such is not the case with the following: Two cars passed through town at 20 miles an hour. One of them was just 100 feet behind the other. As soon as each car reached the city limits, the driver stepped on the gas (sounds natural, doesn't it?) and at 300 feet from the city limits, he was going 40 miles an hour. Each car maintained this speed after reaching it. The problem is: How far apart were the cars after they had both reached a speed of 40 miles an hour?

Faced with this question, most persons with technical training will reply that at 40 miles an hour the cars were twice as far apart as they were at 20 miles an hour, which means that they were 200 feet apart. In justifying this solution, mathematically inclined persons may calculate that the second car reached the city limits 3 9/22 seconds after the first one did. They will figure further than when this rear car reached the city limits, the front car was 125 feet ahead of it, going 30 miles an hour. In 3 9/22 seconds more the front car was 300 feet from the city limits, going 40 miles an hour, while the rear car was 125 feet from the city limits, going 30 miles an hour. In 3 9/22 seconds more the front car had gone another 200 feet at 40 miles an hour and was 500 feet from the city limits, while the rear car had gone 300 feet from the city limits and had attained a 40-mile speed. The cars then remained 200 feet apart.

Other persons, more or less mathematically inclined, may notice (and stick to it after noticing it) that these two cars were always the same number of *seconds* apart. At 20 miles an hour that number of seconds placed them 100 feet apart. At 40 miles an hour it would place them twice as many feet apart: 200.

With the bell-buoy problem, if you can't think of any way in which the two gentlemen could make any more noise, you ought to reverse your tactics and figure some way in which they could make less. Everyone who has seen a bell buoy knows that the two men could easily quiet the bell. To the steamboat crew, the silence of a familiar buoy would be just as disturbing as any amount of shouting. The two men could be pretty sure that if the officer on the bridge did not hear the bell, he would wind up a searchlight and start looking for the buoy, thus discovering their plight.

As for the two iron bars, one of which was magnetized, we need only recall what most of us know: A bar magnet exhibits no magnetic tug at its center. Just one test is necessary to discover which bar is magnetized: Bring the end of bar A close to the middle of bar B; if there is a tug, bar A is magnetized; if there is not, bar A is not magnetized.

Here is a concise little problem brought to mind by the case of the two automobiles aforementioned: A man dropped a rock from his roof. It fell the last half of the distance in half a second. How high was the roof? Of course, this is not much of a riddle if we all remember our introductory physics. But it is interesting, because nearly every engineer thinks he can sit down and solve it out of hand. It is not surprising to find five or ten minutes wasted in false starts before the answer comes out.

A farmer's son once had a problem, the solution of which would not have been speeded by college training. To encourage industry in the boy, his father allotted him a 16th of an acre of ground and told him he could have all the produce from it. The son decided he would plant fruit trees on his tract, and his father told him not to plant his trees any closer than nine feet apart. In laying out the plot, the father made it square, measuring 52 feet, two inches, on each side. (This did not make exactly a 16th of an acre, but it made almost that amount, and it gave the boy exact dimensions with

which to work.) The question was, of course, how to arrange the trees in rows so as to get the largest possible number of trees in the allotted space.

Among the algebraical problems, it is always interesting to find a soluble one which involves three unknowns and only two equations. One such occurs in the case of the three truck drivers who stopped at an all-night dining car for midnight refreshments. One of the men was very hungry and ate four sandwiches, a cup of coffee, and ten doughnuts. His bill came to 85 cents. The second man wasn't so hungry, but he succeeded in putting away three sandwiches, a cup of coffee, and seven doughnuts. His bill was 70 cents. The third man wasn't anywhere near so hungry as the first two. He ate only one sandwich, one doughnut, and one cup of coffee. The problem is: What should his bill have been?

In the foregoing problem the equations are very easily set up. This is by no means always the case and sometimes a satisfactory set of equations is so much trouble to evolve that it is easier to solve the problem by some method of insight or ingenuity. Take, for example, the matter of the suburbanite who took the early train home. Mr. Jones always took the train which arrived at his station at exactly five o'clock. Being a very punctual gentleman, he required corresponding behavior in his employees, so that his chauffeur always arrived at the station at five o'clock, coincidentally with the train. Mr. Jones always alighted from the train, stepped immediately into his car, and was driven home. The chauffeur always drove at the same speed, whether Mr. Jones was with him or not, and whether the road was smooth or rough, crooked or straight. Well, one day Mr. Jones took an earlier train without notifying his chauffeur. He arrived at his station exactly an hour early. Realizing that he would not be met by his car, he immediately started walking toward home. The chauffeur left the house for the station at the usual time, so that after Mr. Jones had been walking for an interval, he was met by the chauffeur. He got into the car and was driven home, where he arrived ten minutes earlier than usual. The problem is: For what period of time did Mr. Jones walk along the road?

With that, we can justifiably abandon algebra, while we consider the case of the four tennis players who are the brain children of a couple of Boston publishers.

Messrs. Biff, Piff, Riff, and Tiff are broker, lawyer, publisher, and advertising man, but not respectively. They played three sets of doubles. The broker was an opponent of the lawyer and played with a racket borrowed from Biff. The broker and his partner won the toss and chose to serve. Riff, a better player than the lawyer, bet the broker on the outcome of the match. The first set went to Biff's side. Piff lost his service in the last game of the first set, and the advertising man won his service in the first game of the last set. The final score was 6 to 4, 3 to 6, 6 to 4. The problem is: What was the lawyer's name?

The solutions of these last five problems have been placed on page 200*f*. so they won't distract anyone who wants to educe them on his own.

To solve the problem of the height of the roof from which the rock was dropped, we take the traditional equation for *s*, the distance *(Continued on page 200)*

Edwin M. Blake

The End of the Trail (Zion National Park)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Stabilizing Enrollment

BEGINNING with the freshman class entering next fall, the Institute will adopt a policy of stabilizing the size of its enrollment, it was announced by President Compton following a meeting of the Institute's Corporation on January 8. This action was taken as a result of the unanimous recommendation of the Faculty, a committee of which has been engaged since last spring in studying the numbers of students which may be accommodated without overcrowding staff and other facilities. The committee has also given consideration to the problem of minimizing the wide fluctuations in registration which have occurred since the War, "to the end that we may at all times seek to give the best training anywhere available in engineering, architecture, and the sciences which underlie engineering, and at the same time use our available facilities most effectively."

The committee believes that the Institute "should aim to admit as high a proportion as possible of men potentially qualified to become leaders in the careers" for which it offers preparation. "To this end," the report continues, weight should be given in admitting students "not solely to scholastic capacity, but also to personal qualities making for all-round effectiveness, such as imagination, adaptability, resourcefulness, dependability, and coöperativeness."

As a first step in putting the stabilization program into effect, the freshman class for the coming two years is to be kept under 600 instead of permitting it to exceed this number as it might if the present trend continues. This year in a total registration of 2540 there are 561 first-year students and in 1934 there were 542. Stabilization will enable the administrative officers to draw plans now for staff personnel for first-year instruction for the next two years. Thus by setting a maximum number of freshman students, the report says, the Institute will avoid the "difficulties of rapidly expanding a staff and still maintaining the quality of its personnel."

The Committee on Stabilization of Enrollment consisted of Dean H. E. Lobdell, '17, Chairman; Professor Nathaniel H. Frank, '23; Professor William H. McAdams, '17; John M. Nalle, '20; Professor Brainerd A. Thresher, '20; and Professor Carlton E. Tucker, '18.

President Compton also announced that as the result of a study by a faculty committee, it has been decided to permit students of all classes, with a cumulative rating of 4.00 and above to take examinations for advanced standing in subjects of prescribed courses for which they have never been registered. The committee found that many capable and ambitious students are anxious to study and pass subjects on their own initiative without instructional assistance, thereby releasing a portion of their time for the study of more advanced subjects. In the upper years, it was suggested, the accumulated term time might well be devoted to graduate subjects in preparation for graduate work. The Committee on Examination for Advanced Standing consisted of Professor Leicester F. Hamilton, '14, Chairman, Professor Henry B. Phillips, and Professor Thomas K. Sherwood, '24.

Radium Detector

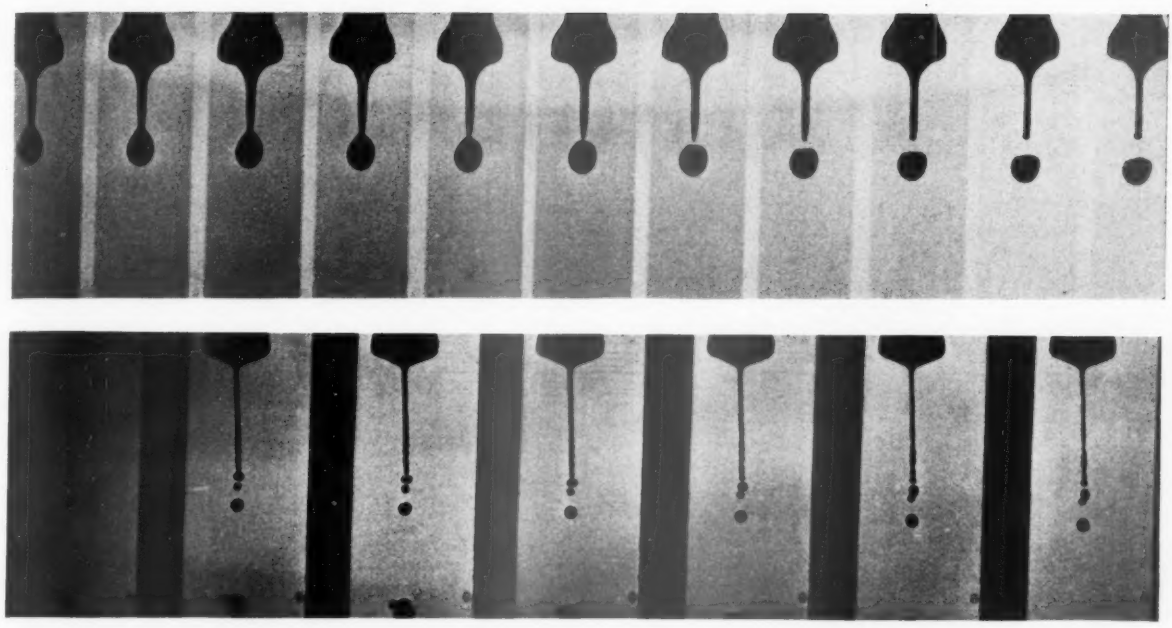
RECENT advances in the physics of radioactivity detection have led to the development in the Institute's Department of Physics of a gamma ray detector, an extremely sensitive instrument for measuring such radioactive materials as radium, thorium, and uranium, by means of their invisible gamma radiations. The significance of this device lies not only in its usefulness for basic studies in radioactivity, but in its application medically for diagnosing radium poisoning.

Radium and its associated decay products continually emit an assortment of penetrating radiations which are hazardous to health, unless safeguarded in ways which have been discovered in the course of developing the use of radium for treatment of cancer and related diseases. When ignorance or carelessness permits, these radiations may induce incurable radium burns or, when radium is ingested, chronic radium poisoning.

Several years ago the cases of five New Jersey girls, who had ingested fatal doses of radium while painting luminous figures on watch and clock dials, attracted wide attention. Hundreds of similar cases remained unpublicized. Post-mortem examinations showed that only ten millionths of a gram of radium, deposited in the bones by body chemistry, would cause death. In spite of this knowledge, some industrial users of radium failed to modify their shop technique so as to protect their workers properly.

Scarcely a month now passes in which a new case of chronic radium poisoning is not discovered. Some of these are industrial poisoning cases, but others arise from drinking radium water tonics and nostrums. Still others are the result of intravenous injections of radium salts, made years ago by uninformed physicians who were unsuccessfully attempting to treat arthritis and other ailments with the unexplored magic of radium.

The gamma ray detector, which was designed by Dr. Robley D. Evans, now makes possible unambiguous laboratory tests which can reveal the presence of chronic radium poisoning five years before any clinical symptoms appear. The development of these instruments is one of Technology's research projects, which will soon make generally available an instrument more than one hundred times as sensitive as those previously used, yet so simple that it can be successfully used by the practicing physician, factory inspector, life insurance examiner, or routine testing laboratory analyst.



Top. *High-speed motion picture (960 exposures per second) showing formation of first drop of benzene exuding from a Traube stalagmometer, as used for relative surface-tension measurements in industry. This picture, as well as the lower one, is selected from a series of cinematographs made by Professor H. E. Edgerton, '27, (Electrical Engineering Department) and Dr. E. A. Hauser (Chemical Engineering Department) during their joint research in using high-speed motion-picture technique for the study of physicochemical and colloidal-chemical reactions. (Watch the flattening out of the drop. This is the first part of an oscillation in drop shape now being investigated in detail with the idea of obtaining more accurate information on surface tension in general.)* Bottom. *Flow of ethyl acetate from the same orifice. The picture shows that the liquid does not wet the lower surface of the stalagmometer, but flows in a continuous stream prior to breaking up in several droplets. The flow, on careful examination, shows column formation. The increasing importance of surface tension in a variety of industrial processes warrants such refined study of the phenomenon*

It is adapted not only to the early discovery of radium poisoning in humans, but to the essential protective work of Federal analysts in detecting radium-contaminated cosmetics, tonics, and nostrums. If backed by adequate legislation, these poisonous products could be quickly removed from commerce.

Toward Better Engines

IMPORTANT studies of airplane engine performance with the object of making improvements in their design is now in progress at the Institute under the auspices of the National Advisory Committee for Aeronautics. In this research, which is being carried on in the Automotive Engine Laboratory of the Department of Mechanical Engineering, two problems are being studied. The first concerns the two-stroke, or what is more popularly known as the two-cycle engine for aircraft. The advantage of this type of engine, which has long been recognized by engineers, is that it gives one power impulse per revolution instead of one in two revolutions as in the four-stroke engine. Furthermore, the ported two-stroke engine is perhaps the simplest prime mover known and as such it is inexpensive to manufacture.

In the present stage of knowledge the design of the two-stroke engine is much more difficult than the conventional four-stroke power plant. As a result the two-stroke type has not been used extensively in aircraft. The difficulty of design of the two-stroke engine is largely due to the fact that the burned gases cannot be forced out of the cylinder by means of the piston as in the four-stroke engine, but must be displaced by the incoming charge. This must be accomplished with a minimum amount of mixing of the burned and unburned charges, and with the least possible loss of fresh charge through the open exhaust valve. The process of displacing burned gas by means of fresh charge, known as "scavenging," is the particular problem now under investigation.

The Institute's engine laboratory is particularly well fitted to carry out this investigation because of work previously done here on direct fuel injection, which definitely improves the fuel consumption and control of two-stroke engines, and because of special facilities for investigating the charging of the cylinder.

The second investigation in this research program concerns the dynamic characteristics of the induction system of conventional engines. By virtue of its mass, the air in the inlet pipe of an engine tends to continue to flow after it is once started. Because of this phenomenon, it is possible, without supercharging, to fill the cylinder of an engine with air at several pounds higher than atmospheric pressure, thereby increasing its output. The Automotive Engine Laboratory has been engaged in work along these lines for some time with a high degree of success, for, by proper regard for the dynamics of the inlet system, it has been found possible to achieve the effects of a moderate degree of supercharging. The results of this work are already having effect upon modern aircraft engine design, and it is

hoped that its completion will produce important data for improvements in the design of the induction system.

Science at St. Louis

THE Institute was appropriately represented at the recent annual meeting of the American Association for the Advancement of Science at St. Louis by President Compton and Vice-President Vannevar Bush, '16. As retiring president of the association, Dr. Compton made the reply to the address of welcome at the opening session on December 30, and was busy throughout the week at various technical and business meetings. On January 2, Dr. Bush gave the Josiah Willard Gibbs Lecture, choosing as his subject, "Instrumental Analysis," a field in which he is internationally distinguished. It will be recalled that last year he was invited to address the Fourth International Congress of Applied Mechanics in England on the subject of analyzing machines.

Among the many important papers presented during the meeting was one by Arthur C. Ruge, '33, Research Associate in the Department of Civil Engineering, on "A Machine for Reproducing Earthquake Motions Direct from a Shadowgraph of the Quake." The paper, read for Mr. Ruge by Captain N. H. Heck of the United States Coast and Geodetic Survey, concerned the design and operation of the unique shaking table described in detail in The Review last month.

In the huge exhibition hall, the Institute was represented by an exhibit of scientific and engineering instruments and research apparatus illustrating important investigations now in progress at Technology. These included Professor Evans' gamma ray detector (see page 186), and an instrument for analyzing radio listening habits, developed by Professors Louis F. Woodruff, '18, and Robert F. Elder, to study the effectiveness of radio programs. The Van de Graaff method of generating high-voltage direct current was demonstrated by a table model of the huge generator, built at the Institute's research station at Round Hill. The division of aeronautical engineering of the Department of Mechanical Engineering contributed a gyro-drive testing device, which makes it possible to study variations in rotor speeds in aircraft instruments due to changes in altitude and atmospheric pressure. A stroboscopic lighting device designed by Professor Harold E. Edgerton, '27, is used in this apparatus for stop-motion studies of the behavior of rotors at various speeds.

Another exhibit was a lithium-fluoride crystal three inches in diameter, grown by Dr. Donald C. Stockbarger, '19, of the Department of Physics, and described in The Review in January. The Department of Biology and Public Health contributed a hot-wire thermal precipitator for sampling dusty atmospheres. This device, designed in England for the Medical Research Council, was constructed at the Institute for research to determine the density of dust to which industrial workers are exposed. Dr. Ralph D. Bennett of the Department of Electrical Engineering provided a directional cosmic-ray counter, in the design of which he had an important part. Photomicrographs of textile fibers in color were shown through the courtesy of Professor Edward R. Schwarz, '23. Photographic plates of the spectrum, provided by Professor George R. Harrison, and progress photographs of the scale model of the Cape Cod Canal built under the direction of Professor Kenneth C. Reynolds, '25, added much to the interest of the exhibit. The coöperation of Frederick B. Wolf, '28, Secretary of the Technology Club of St. Louis, in arranging for assistance in presenting the Institute's exhibit was responsible to a large degree for its success.

Alumni Day Plans

WE ARE enthusiastic over the plans now being developed for Alumni Day, which falls this year on June 8. Among the items on the program will be an important conference, to which all alumni are invited, on transportation. Invitations are being issued to nationally known figures in the four major transportation fields — rail, air, highway, and water — and with these actively participating in the conference, attending alumni will be assured of a stimulating and provocative symposium.

This conference, together with the social events and departmental meetings on the program, will provide a reunion that will be important as an educational event, enjoyable as an opportunity to renew Technology contacts, and entertaining as an alumni festival.

Sail Ho!

THE proposal recently submitted at a mass meeting of undergraduates of the Institute that sailing be made a student activity, received an enthusiastic response, and plans have already reached the stage where it is possible to announce that a fleet of sailing dinghies will be ready by spring. Twenty-five boats are assured and the prospects are that when the ice leaves the Charles River Basin the bright colored sails of at least thirty will make the river as picturesque as the Zuider Zee crowded with Dutch boats.

The enthusiasm of the students for the new activity is matched by that of Professor Erwin H. Schell, '12, Head of the Department of Business and Engineering Administration, whose efforts have been largely responsible for the rapid progress and the donation of dinghies by members of the Corporation and Alumni.

Small-boat sailing, particularly in the Frostbite type of dinghy, has developed swiftly in the past few years, bringing to thousands the pleasures and benefits of a sport which hitherto has been somewhat limited by the expense of boats. The new small dinghies are relatively inexpensive and offer every opportunity for learning the science of sailing.

Technology will probably be the first college in the country to include the sport in its official undergraduate program. Several colleges have private student sailing clubs, but undergraduate leaders have found no record of a recognized sailing activity.

President Compton, who considers sailing a healthful recreation and wholesome training, donated the first dinghy, and others were presented by Alfred L. Loomis; F. Wright Fabyan, '93; Lammot duPont, '01; Lyall L. Stuart, '21; Barron P. Lambert,*(Continued on page 189)*

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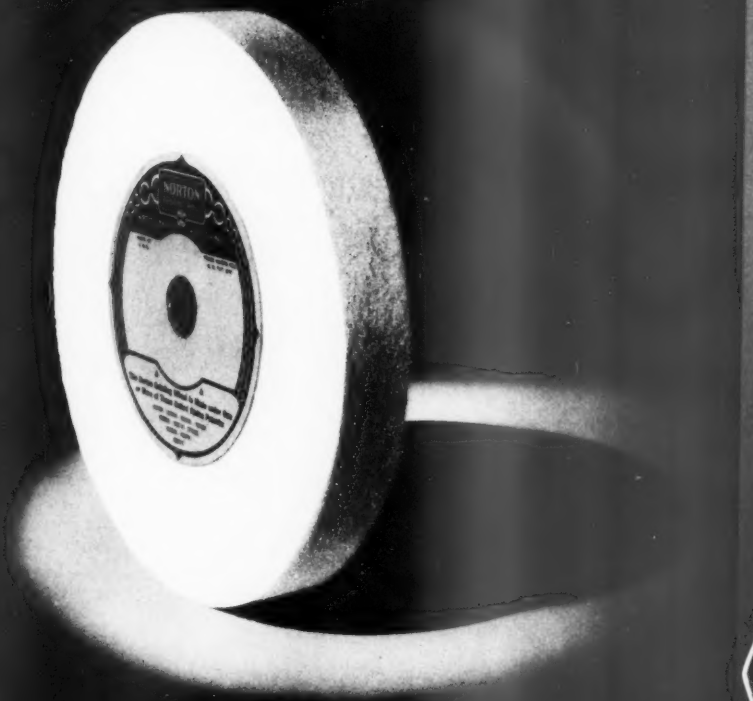
Grinding Wheels

Keeping Step with Industry



WHEN automobile manufacture started on a production basis, Alundum abrasive came into the field. With it came new standards of machining accuracy and speed.

The introduction of new alloys, harder materials, brought other Norton developments—abrasives such as #38 Alundum, Crystolon and Norbide —new bonds, notably B bond; a manufacturing process by which wheel structure is controlled; wheels made of commercial diamonds.

Thus Norton abrasive products have kept step with developments in land and air transportation, communication and agriculture. Norton Research has kept step with the metallurgist and the designer.

It is the combination of correct abrasive, right type of bond and ability to duplicate the wheel hardness and the wheel structure that makes for correct cutting action.

NORTON ABRASIVES

NORTON ABRASIVES

Refractories

MODERN industry uses heat in many ways. High temperatures—special refractories.

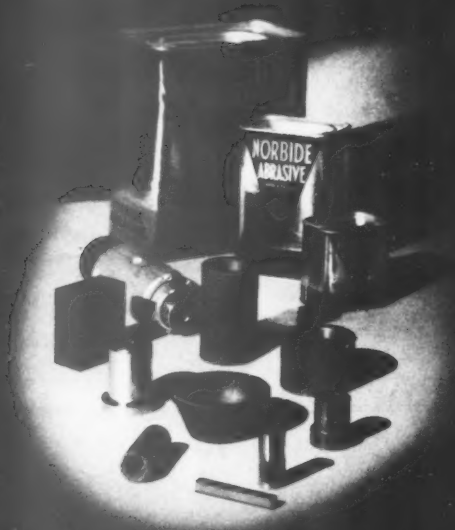
Norton research has developed many types of media for handling heat under a variety of conditions.

For example—Alundum and Crystolon Bricks, Plates and Cements for boiler furnaces, heat treating furnaces, melting furnaces, enameling furnaces, ceramic kilns.

Among the developments also is Alundum Laboratory Ware for ignition, incineration and filtration.

For aerating, diffusing and filtering liquids, solids and gases, we have Norton Porous Plates and Tubes—highly efficient in many modern sewage plants of the activated sludge type.

Norbide



NORBIDE—the hardest material ever produced by man for commercial use—is one of the outstanding developments of the Norton Research Laboratories.

Industry has found many uses for Norbide—it is available in molded form where exceptional hardness and resistance to wear are desired and in abrasive form for jobs previously done with diamond dust—such as the drilling and lapping of cemented tungsten wire drawing dies. Norbide Pressure Blast Nozzles have made great savings in each industry where there has been a problem of fast wearing nozzles.

Norbide is the trade-mark for Norton Boron Carbide (B_4C).

Main Office and Plant

NORTON COMPANY

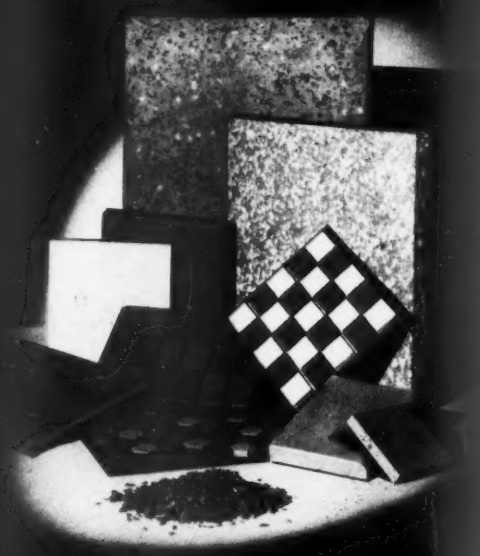
Worcester, Mass.

Electric Furnace Plant: Chippawa, Ontario
Branch Grinding Wheel Plants
Hamilton, Ontario
Welwyn Garden City, England
La Courneuve, France
Wesseling, Germany
Corsico, Italy

Sales Offices: New York, Chicago, Detroit
Philadelphia, Cleveland, Pittsburgh, Hartford
London Paris

NORTON ABRASIVES

Floors

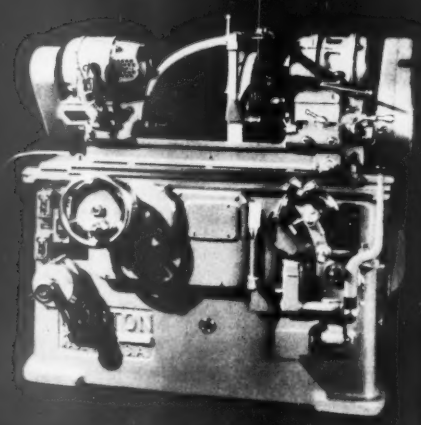


NON-SLIP tiles, treads and aggregates of Alundum abrasive are marketed under the name "Norton Floors." Because of the hardness and toughness of Alundum abrasive, so efficient in working steels and other metals, a walking surface containing a correct proportion of it is sure to have wear-resisting properties.

Industry finds the Alundum Rubber Bonded Safety Treads excellent for stairway maintenance—likes its permanent safety, its easy application. Cement floors reinforced with Alundum Aggregate have solved rather serious factory flooring problems—providing safety and durability.

Norton Floors meet about every problem where a non-slip walking surface is desirable to eliminate a slipping hazard.

Machines



THE Cleveland show crowds marveled at the Norton D-86—a hydraulically operated machine for grinding pins of crankshafts.

Another new and appealing design was the Cam-O-Matic for automatically grinding the cam contours of camshafts, electrically controlled, hydraulically operated.

They are two examples of the line of Norton machines designed to meet specific requirements of modern industry.

Other recent designs are the Type "C" line of cylindrical grinders with semi-automatic, plunge-cut and traverse models, the small Surface Grinder, two Tool and Cutter Grinders and new Lapping Machines for both cylindrical and flat work.

Polishing Abrasives

To meet present polishing wheel requirements attention must be given to character of abrasive, shape of grain, surface of grain, capillarity and to a uniformly sized product.

Six types of Alundum Abrasive—two types of grain shapes, three types of grain treatments in each—are available.

Norton Laboratories have a completely equipped polishing department for experimental work. The call for their services comes from the metal, stone and glass industries. A special product known as Norton Lens Finishing Flour is used in optical work. Especially prepared Crystolon Abrasive is meeting with a high degree of success for stone polishing and in glass work.

Sharpening Stones

The bench stone—most familiar of oilstone shapes—may be artificial or natural. Best known is the India oilstone—made of Alundum abrasive. If a slightly different cutting action is desired, a different edge required on the tool, a stone of Crystolon abrasive can be used.

The natural stones are: Hard Arkansas, Soft Arkansas and Washita. The sharpening stone catalog lists a surprising variety of shapes and sizes of sharpening stones, hones and abrasive files. The biggest surprise is the many shapes of small stones for die and tool work.

The sharpening stone line is sold by Behr-Manning, division of Norton Company, Troy, New York, manufacturers of coated abrasives, sandpaper.

NORTON COMPANY
Worcester, Mass.
Behr-Manning Corporation, Troy N. Y.
Division of Norton Company

NORTON ABRASIVES

人体解剖学

XU

'26; Marshall B. Dalton, '15; J. Franklin McElwain, '97; Paul W. Litchfield, '96; William R. Kales, '92; J. Howard Pew, '03; Francis C. Holmes, '92; Duncan R. Linsley, '22; Philip Stockton, '99; Frederick T. Moses, '07; Richard L. Bowditch, '23; Arthur C. Dorrance, '14; Philip W. Moore, '01; Henry E. Warren, '94; W. Clark Arkell, '10; Frederick A. Flood, Donald W. Douglas, '14; Luis deFlorez, '11; and E. Leland Wemple, '08. The twenty-fifth boat was donated anonymously.

President Compton appointed a committee to design a boat suitable for racing as well as for training a large number of students. The design has been completed by the Department of Naval Architecture and Marine Engineering and dinghies will be built immediately. Professor George Owen, '94, is chairman of the committee and his associates are Henry A. Morss, '93, of the Corporation, and Walter C. Wood, '17, of Providence, R. I.

Meantime students are learning the fundamentals of sailing in free courses given by Professor Owen, designer of many famous yachts and a skillful skipper, and Robert W. Vose, '31, of the Department of Mechanical Engineering. The course will be supplemented with lectures by prominent yachtsmen.

With more than 400 students signed for the activity and an instructing staff of more than 100 undergraduates whose sailing experience fits them to introduce landlubbers to the sport, sailing promises to become one of the most popular of the Institute's thriving student activities.

Physics at M.I.T.

BELOW is a condensation of an important report recently presented to the Corporation by its Visiting Committee on the Department of Physics.

DEPARTMENT OF PHYSICS*

As physics is the backbone of all the sciences and of all the various branches of engineering, the members of the Committee were especially interested in hearing in considerable detail about the undergraduate courses and in learning of the close relations existing between the work of the Department of Physics, on the one hand, and of the Departments of Mathematics and Electrical and Mechanical Engineering, on the other. The Committee wishes especially to endorse the emphasis which is being placed on methods and principles rather than on formulas.

The teaching of the first two years forms a large part of the teaching load of the Department and is the period at which most contact is made with other departments. During the past year, interesting developments have occurred both in freshman and in sophomore work. The freshman subjects, 8.01 and 8.02, have been evolving gradually for a number of years, under the guidance of Professor Frank, '23. This year a particular effort has been made to correlate them with the applied mechanics given by the Mechanical Engineering Department, and in this connection, members of the staff of that department have been visiting the classes in 8.01 and 8.02 and have made interesting comments and suggestions. The first few weeks of the term, in particular, seem to present difficulty, and it was suggested that the work in statics might well be given at the beginning, instead of work in kinematics and dynamics. The correlation between physics and mathematics in these first few weeks is particularly important, since the student must at the same time learn the fundamental ideas of calculus, and must apply these to his kinematics and dynamics. Though a careful correlation is made at present, it would give the student more time to assimilate his mathematics if statics, which does not demand calculus, were placed at the beginning. It is understood that a modified form of this arrangement will be tried during the coming year. A further suggestion from the Mechanical Engineering Department is that the units and nomenclature, both in mechanics and heat, should be uniform in the two departments.

In regard to the sophomore electricity and optics, 8.03 and 8.04, a new development has been undertaken this year in connection with the Electrical Engineering Department. The sophomore students of Courses VI, VIII, XIV, and XVIII have been put in a special group of 8.03 and 8.04, under the direction of Professor Wulff. They are able to undertake a somewhat more thorough course of study in electricity than the students of other courses. This subject starts with a more fundamental treatment of electrostatics than could be given to the sophomores of other courses and carries the treatment of electricity up through Faraday's induction laws in the first term, then treats the remaining electrical topics, electric waves, and optics, in the second term. Though the program is ambitious and the work difficult, the students this year do not seem to find it beyond their ability. The students in Courses VI, VIII, and XIV now take electrical engineering 6.00 in the second term of the sophomore year, and the Electrical Engineering Department is revising this subject, so that it is now a fundamental treatment of electric circuits in theory and practice, carefully correlated with the material presented in the special sections of 8.03 and 8.04. This development has been arranged by close coöperation between members of the staff of the Departments of Physics and Electrical Engineering. The Electrical Engineering Department had come to feel that the fundamentals of electromagnetic theory should be presented to all the students of the Department at an earlier period of their training, and has been working out a basic course to be taken by all students, starting with fundamentals and including, later, the branches of electricity needed for all types of practical work. In connection with this revision, the coöperative scheme with the Physics Department has been developed, in which the training in electricity is carried in a continuous way from the beginning of 8.03 through the whole basic course. . . .

Graduate Work

The members of the Committee have been greatly impressed by the enthusiastic scientific spirit of the staff, also by the volume and quality of the scientific

*The Visiting Committee which made the above report consisted of: William D. Coolidge, '96, Chairman, Alfred L. Loomis, Frank A. Vanderlip, Donald G. Robbins, '07, Charles G. Abbot, '94, Bailey Townshend, '16, Henry A. Barton, F. K. Richtmyer.

work of the Department, shown in the large number of papers recently published. However, since the meeting of the Committee held during the year 1933 to 1934 was devoted almost entirely to the purely scientific research of the Department, this phase of the Department's activities was not elaborated upon at the present meeting.

The subject of applied physics has attracted considerable attention during the past year. A conference on that subject was held jointly by the American Institute of Physics and the National Research Council in the course of the year, focussing the attention of both physicists and industrial leaders on the possibilities of applying physics to industry, and this question was made a principal topic of discussion at the meeting of the Committee. Through the activity of the Division of Industrial Coöperation and Research, the industrial cooperative courses, and other vital connections with industry, the Institute is in an especially favorable position to offer instruction in applied physics, and with the new Eastman Laboratory, the equipment of the Institute for graduate work both in pure and applied physics is unexcelled. There is already a large amount of work in applied physics being carried on in the Department, particularly in the line of research.

Professor Harrison, in the development of his spectroscopic program, is working on the applications of spectroscopy (including both qualitative and quantitative spectroscopic analysis) to a wide range of problems in chemistry, metallurgy, and biology, and is attracting much attention among experts in those fields, especially in connection with his summer spectroscopic conferences. Professor Hardy's, '18, work in color measurements, including the development of the color analyzer, is opening up a new era in those industrial fields — textiles and dyestuffs, printing ink, and so on — which depend on accurate measurement of color. Professor Warren, '24, in his researches on crystal structure of minerals and glasses, is in a field where he makes constant valuable contributions to the geologists, and to workers in the fields of ceramics and glass technology. In a somewhat related field, Professor Stockbarger, '19, by his improvement of the method of crystallizing lithium fluoride and other compounds from the melt is developing these substances into optical materials of real importance. Much of Professor Nottingham's work on thermionic emission is of importance to the electrical industry, where understanding of thermionic processes is essential in connection with vacuum-tube technique. Professor Van de Graaff's work on high voltage, though undertaken primarily as a tool in the field of nuclear research, has led to developments in the technique of high-voltage production and control which, with the collaboration of the Electrical Engineering Department, promises valuable advances in the engineering field. Much of Professor Evans' work in radioactivity represents another practical application of nuclear research, though to other sciences rather than to industry, since it is concerned with the geological problem of the age of the earth, on the one hand, and with biophysical applications, on the other. Professor Wulff has been making investigations of the properties of surface films on metals, which should be of importance in the problem of corrosion. Finally, on the theoretical side, much of the work of Professors Stratton, '23, and Morse is of practical importance in such varied fields as electrical and acoustical radiation, hydrodynamics, and internal-combustion engines. A number of other projects in the Department, bearing more or less directly on practical applications, could be mentioned. It will be seen, however, that these all refer to research rather than to the training of physicists for industrial and applied work.

Wide World

Dr. Warren K. Lewis, '05, Professor of Chemical Engineering at Technology, receiving the Perkin Medal on January 10 from Professor Marston T. Bogert of Columbia, "in recognition of his activities as the father of modern chemical engineering and his training of and inspiration to many of the present and potential leaders of the profession"

Before considering the training of the applied physicist, it is well to survey a few of the fields with which he is likely to be concerned and types of problem met there. The applied physicist in industry is likely to meet new and unusual problems, and should be able to solve them better than the engineer with his more restricted training. Much industrial research in physics involves, at the same time, problems in chemistry and in the properties of materials, and it is of the greatest importance that the applied physicist should be well trained in chemistry and should be at home in a wide variety of fields. In many cases, physical chemists rather than physicists are employed, even for investigations that are really more physics than chemistry, for the chemist knows the necessary part of physics, whereas physicists often know no chemistry. Nevertheless, there are many research problems in industrial laboratories which need the sort of logical training which the physicist receives, rather than the more empirical point of view of the engineer, and it is likely that works laboratories will, in time, employ better trained men. It is imperative, however, that these men have a broad training, rather than a narrowly specialized one.

In addition to positions for applied physicists in industry, there are a number of other fields in which applied physicists would be useful and which physicists in many cases have not entered. For example, geophysics, involving a knowledge of classical physics and of geology, might be much developed, if suitable physicists

could be found. At present, electrical engineers are largely employed for this work. Nevertheless, good physicists and mathematicians have taken the lead in this field. Biophysics is a field which is rapidly developing and few physicists have entered it, in spite of the fact that almost no biologist is equipped with enough knowledge of physics to fit him for it. Not only in the purely scientific side of biophysics, but also in the medical and therapeutic side, there is a large field for the physicist with biological training, as for instance in the medical uses of x-rays, radioactivity, and high voltages. The subject of x-ray crystallography is generally pursued in industrial laboratories by chemists, because they have the necessary knowledge of the materials concerned, but physicists are much better fitted to do it, by reason of their better mathematical training. Consulting physicists and physicists engaged in patent law are altogether too rare, and those interested in applied physics would do very well to go into these fields, making physics a profession, instead of merely looking for jobs. Doubtless in other fields where physicists are not employed at present, openings for them could be found. It would be very appropriate for such an institution as the American Institute of Physics to make a survey of opportunities for physicists in industry.

With these considerations in mind, the training of applied physicists can be taken up. This training should differ from that of the pure physicist, partly in factual content, partly in point of view. The viewpoint of the academic physicist is that he is interested in applying existing knowledge for practical purposes. A part of the training should consist in emphasizing this difference in viewpoint. In addition, however, applied physicists should receive different information in their courses. They should have more training in chemistry and the properties of matter than the average physics student receives. They should be given a broad training in many fields of physics, and should be made to feel confident and at home when attacking new problems. In general, they do not need as complete a training in mathematical physics and in modern physics as is necessary for research in those branches of pure physics which are developing most rapidly at present. The emphasis on chemistry and the properties of matter is a rather difficult one to make, for students of physics in general do not seem to be much interested in chemistry. This is probably on account of its method of presentation by teachers of chemistry, in which chemical facts are often not presented as part of a logical system, but as a series of isolated experiments which constitute a tax on the memory and appear to be unrelated. It might be better if the student of physics could be presented early in his chemical career with the atomic theory and a picture of electron configurations, followed by a presentation of the periodic table, so as to perceive an order in the experimental facts. Such a course on properties of the elements and compounds, presented from the point of view of the periodic table should, of course, be followed, for the student of applied physics, by a brief course on the simpler organic compounds and after this by a thorough course in physical chemistry. Such a chemical training, together with most of the experimental physics which the physics students learn, the simpler parts of mathematical physics, and the descriptive parts of modern physics, should be the backbone of a course in applied physics. . . .

Presented by Charles Hayden, '90, this memorial cup to the late Allan Winter Rowe, '01, will serve as a trophy for a new Henley rowing regatta on Lake Quinsigamond, Worcester, Massachusetts

The Committee concurs with the members of the Department in feeling: that more attention should be given to the training of physicists for industrial research; that these men should be given a different training from those who are to enter the teaching profession; that they should have more chemistry, more practice in the application of the simpler branches of mathematics, and more familiarity with the properties of materials. The Committee, therefore, wishes to endorse heartily the plan, going into effect next year, of giving a doctor's degree for work primarily in applied physics. It seems that men working for this degree can be given a training which will fit them better than either the Ph.D. or the engineering training of the past for the work of the industrial laboratory, as well as for work in such borderland sciences as biophysics, geophysics, and patent law.

College Pensions

THE provisions of the social security law exempting colleges from participation in the national retirement plan and in taxation for unemployment compensation, emphasizes the urgent need for independent retirement plans in all such educational institutions. So declared Rainard B. Robbins, Secretary and Actuary of the Teachers Insurance and Annuity Association of America, in an address before the 16th annual meeting of the Association of University and College Business Officers of the Eastern States of which Horace S. Ford, Treasurer of the Institute, is Secretary.

Speaking on "The Retirement Problem," Mr. Robbins discussed various college pension plans, directing

attention to the fact that although educational institutions had been leaders in providing for security in old age, only about one third of the nation's colleges have retirement plans.

In his discussion of the social security law and its effect on colleges, Mr. Robbins said: "This law offers a national subsidy to the states for relief of specified needy classes, undertakes to encourage states to enact laws for unemployment compensation and establishes a Federal, compulsory, jointly contributory, retirement plan that will cover about half of the gainfully occupied persons of the United States. Participation in this plan is independent of rank or salary; there is no such thing as a waiting period. . . . The retirement plan and the arrangement for unemployment compensation are the parts of most interest to employers. Employment for educational institutions is excepted from both of these sections of the law so that colleges and their employees cannot participate in the national retirement plan. . . .

"In the future, when half of all gainfully occupied persons are being taxed to provide for noncashable retirement benefits, the college that lays no plans for retirement of its employees, whether faculty, clerical, or manual, will be offering employment, that in this essential particular, will be less attractive than will then be required of all industrial employers engaged in business for profit. It, therefore, seems probable the Social Security Law will encourage the creation of retirement plans in colleges that have none. . . ."

THE OIL-SHED FALLACY

(*Continued from page 182*)

dynamically similar if they are first geometrically similar, and then operated under such conditions that the combination variable ZN/P has the same numerical value for the model and the full-sized machine, and provided certain other requirements are fulfilled. Under these conditions the friction loss can be predicted for the larger machine from observations on the model, since the coefficients of friction will be identical in the two cases. In fact, all performance characteristics will be identical which can be expressed by *dimensionless variables*. Observations on different oils, at all temperatures, speeds, and loads within the range of thick film lubrication, may be coördinated on a single chart by plotting against ZN/P.

The now familiar ZN/P principle, as described above, was first used by the writer (with an unpopular Greek letter in place of Z, to represent the viscosity) over twenty years ago in publishing the results of his experiments conducted under Professor Gaetano Lanza at the Institute. Another interesting conclusion from the dimensional theory of lubrication is that the load capacity of any bearing, defined as the load which reduces the film thickness to some arbitrarily chosen safe value, must be directly proportional to the viscosity multiplied by the speed. This has been confirmed experimentally, thus neatly disposing of the "$P\ V$ fallacy," according to which the safe load would be inversely proportional to the speed. These conclusions followed very simply from the theory of dimensions, a method of attack which had already been found useful in aeronautics, hydraulics, and other branches of engineering.

Temperature Rise in Bearings

In the continued operation of any machine the bearing temperature slowly rises until, after several hours, it may arrive at a steady value known as the equilibrium temperature. In the earlier days of lubrication theory the calculation of this temperature was considered to be an exceedingly puzzling, and possibly an indeterminate, problem. Yet until the permanent running temperature is known, the viscosity factor entering the hydrodynamic equations must be treated as an unknown quantity. A rational solution was found by setting up three simultaneous equations defining the heat transfer characteristics of the bearing, the mechanical friction law for the bearing, and the viscosity-temperature characteristics of the lubricant. These three equations involve three unknowns, H, Z, and T, all remaining factors being treated, for the time being, as constants. The first equation is an empirical one expressing H, the heat (in work units) generated by friction and transferred per unit time, as a function of the temperature elevation T. The second equation, either empirical or derived from the hydrodynamic theory, expresses H as a function of the instantaneous viscosity, Z. The third equation gives Z as a function of T. A definite solution for all three quantities may now be obtained either analytically or graphically, according to the complexity of the particular problem. Detailed results will be found in the September, 1935, issue of the *Journal* of the Franklin Institute.

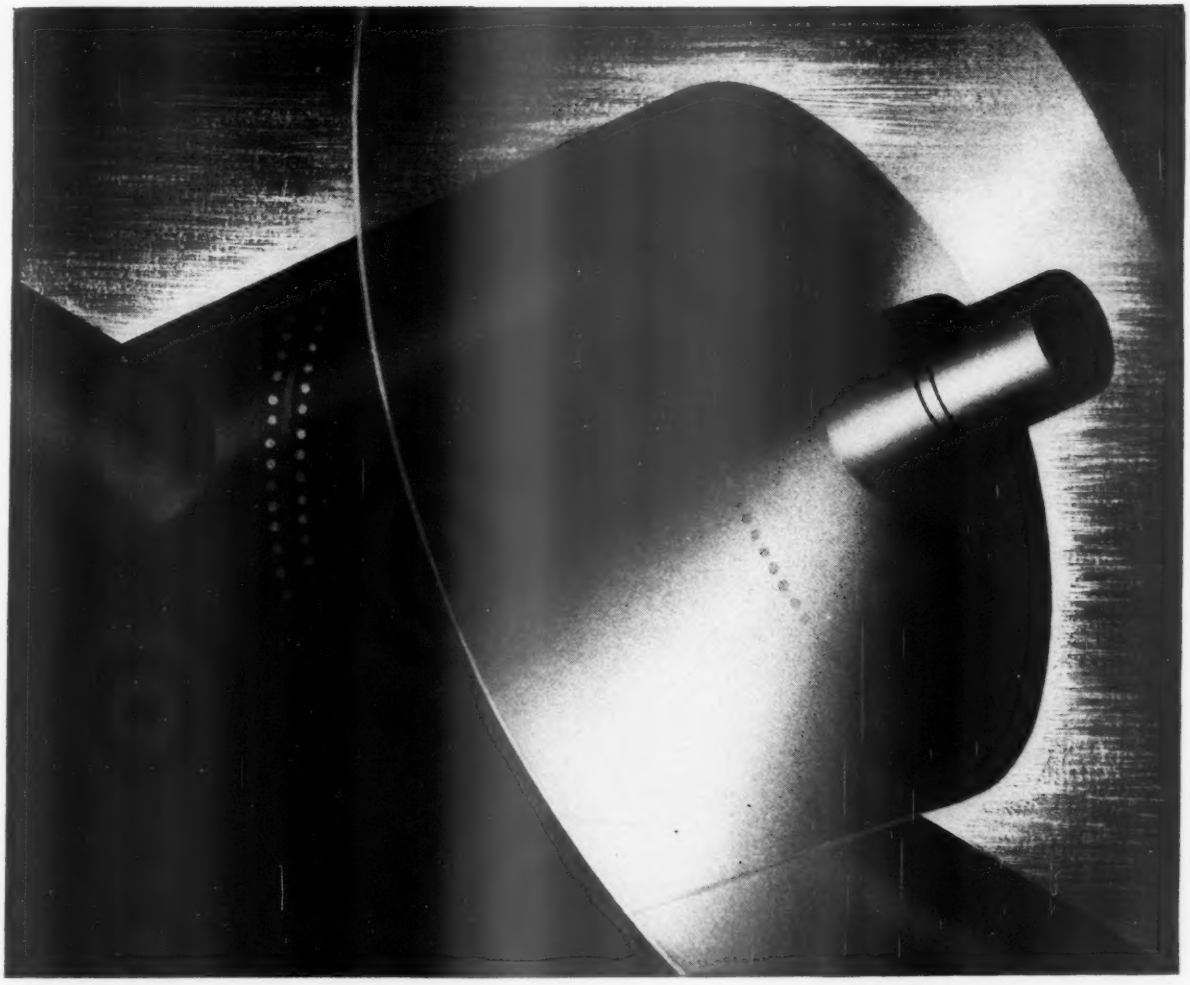
Imperfect Lubrication

When the load is too great, the speed or viscosity too low, the surfaces parallel, or the quantity of lubricant insufficient, a condition known as imperfect lubrication will be experienced, involving more or less metallic contact, followed by wear or seizure. These conditions have been investigated to some extent in connection with gear lubrication and have resulted in the development, by the petroleum industry, of E.P. (extreme pressure) lubricants. Such lubricants contain chemically active addition-agents which, in the language of Professor Buckingham, of the Institute's staff, have the character of an "anti-flux," and so prevent welding or seizure.

Even under conditions which are not sufficiently severe to produce any significant amount of wear, the friction may be influenced by some other property of the lubricant besides the viscosity, as ordinarily measured in bulk at atmospheric pressure. When two lubricants having the same viscosity, as ordinarily measured, give different coefficients of friction under identical test conditions, they are said to differ in *oiliness*. The lubricant giving the less friction is said to possess the greater oiliness.

High-Pressure Experiments

Many very interesting hypotheses have been put forward to explain the performance of lubricants under imperfect lubrication conditions. (*Continued on page 194*)



MOLY makes better surface-hardening steels

IT WOULD be difficult to find a better test of surface-hardened steels than in airplane engines. Cylinders, knuckle pins, propeller shafts, crankshafts and various gears are subjected to particularly severe service. . . Hence the large number of instances in which such parts are made of Molybdenum surface-hardened steels.

There are also many other applications, outside the airplane field, in which the outstanding quality of "Moly" surface-hardened steels to meet the hardest of service requirements has been demonstrated over and over. Whether the process is carburizing or nitriding, the results are the same — and are dependent on the Moly content.

The practical reasons are easily explained. . . Moly increases the speed of penetration and gives a deeper, harder case. The core physical properties are exceptionally good, and there is no susceptibility to temper embrittlement. Distortion on quenching is slight — and uniformly predictable.

Moly cuts costs . . . It reduces the processing time in surface-hardened steels; lowers the rejection percentage. Moly improves steel . . . It makes it stronger, tougher, more resistant to wear, creep, corrosion. Moly creates sales . . . It makes a more serviceable, longer-lasting, more satisfactory product.

A more detailed account of "industry's most modern and versatile alloy" is given in our interesting technical book, "Molybdenum," which is yours for the asking. And, "The Moly Matrix," published periodically, will keep you informed on the latest Moly developments. Shall we put you on the mailing list? Climax Molybdenum Company, 500 Fifth Ave., New York.

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THE OIL-SHED FALLACY

(*Continued from page 192*)

Whatever may prove to be the complete explanation, one simple factor that can hardly be ignored is the change in viscosity which occurs in the lubricant wherever the local pressure is sufficiently high.

The writer's first experiments on this subject, published in 1916, showed that a perceptible increase of viscosity would be caused by a very moderate pressure, the effect being less for lard oil than for a mineral oil of comparable viscosity. This work was begun in Professor Bridgman's laboratory at Harvard University. The investigation was subsequently taken up by Hyde at the National Physical Laboratory in Teddington, by Kiesskalt at Karlsruhe, by Kleinschmidt and others at Harvard, and by Suge at Tokyo.

More recent experiments by the writer, conducted at M.I.T. with Henry Shore, '24, have shown that the viscosity of lard oil, at 72 degrees F., is increased fourfold by the application of a pressure of 15,000 pounds per square inch; and that this oil solidifies, or becomes suddenly plastic, at about 21,000 pounds per square inch. A medium mineral oil of asphaltic base, at the pressure and temperature first mentioned, increased in viscosity six times as much as the lard oil, or about twenty-four fold. At 194 degrees F. it increased but without solidification, until at 60,000 pounds per square inch the viscosity of the mineral oil had gone up to approximately three hundred times its original value.

Rolling Friction

A complete program of friction research should include the study of rolling friction and dry-sliding friction, as well as the friction of lubricated surfaces. The laws of rolling friction apply to car wheels of every description, as well as to automobile tires and the mechanism of ball and roller bearings. The laws of dry-sliding friction apply to friction clutches and belting in factories, and obviously to brakes, a subject of rapidly increasing importance in view of the newer railroad developments.

An amusing experience in the testing of mine cars will illustrate the significance of rolling friction. A ball-bearing car was submitted by the bearing manufacturer in competition with two different types of roller-bearing cars. The friction should be less for the ball bearing than for any type of roller bearing, other factors assumed equal. To the surprise of everyone, the ball bearing car, No. 1, showed the highest friction of the lot, while one of the roller bearing cars, No. 2, gave almost double the friction expected. It was revealed upon inquiry that the ball bearing wheels had been unskillfully cast in a local iron foundry, and came out exceptionally rough. The wheel surfaces of car No. 2 had been turned down accurately in a lathe, thus eliminating the roughness, but removing the harder skin of the casting. The softer metal exposed created noticeably more rolling resistance, with the result that car No. 3, fitted with ordinary wheels, won the test. The true relative merits of the respective bearings were concealed by unnecessary differences in rolling friction between wheel and rail.

(*Continued on page 196*)

★

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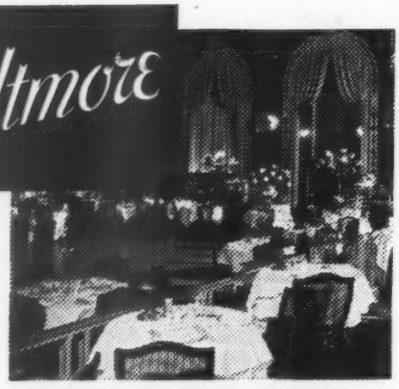

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THE OIL-SHED FALLACY

(*Continued from page 194*)

Economics of Friction

A mechanical engineer in Pittsburgh was asked by the management of a steel mill to make a complete analysis of their power distribution and friction losses. His report was an eye-opener: from 40% to 50% of the power delivered to the rolls was consumed in the roll-neck bearings alone, with a total power loss of 90% for all the machinery in the mill. These conditions still exist in many large mills and factories in various industries but are being improved by the introduction of roller bearings and by scientifically designed plain bearings with oil film lubrication. Improvements are constantly being made in each type as the laws governing their mechanical action come to be better understood.

Every wheel that turns must overcome friction, from the smallest balance wheel of a wrist watch to the thrust bearings of a modern steamship or hydroelectric power plant. The total tax in energy so extracted amounts to a figure that no politician would venture to propose in terms of money; yet the law of the conservation of energy might be extended to read that all the industrial power converted into heat by friction is finally converted into an item of cost on the debit side of the ledger.

How to reduce the amount of this loss is one of the great problems of lubrication research. Other objectives are to lengthen the life of the bearing surfaces by minimizing wear, to avoid loss of time for repairs, and to economize space by reducing the area of the rubbing surfaces. Surprising results have already been accomplished. The modern pivoted shoe thrust bearings for propellor shafts occupy much less space than the older type, or multiple-collar bearings, and consume only one tenth as much power.

The economic significance of Newton's first law of motion is probably not fully appreciated by all engineers and industrial executives. Take, for example, railway transportation. How many people stop to think that if it were not for the air resistance, rolling friction and flange friction on the rails, bearing losses, and other forms of friction, no fuel would be required to maintain a given velocity on level track indefinitely? The popular assumption that velocity, as such, requires power is, of course, fallacious.

It is also interesting to remember that in a period of depression, friction losses account for a larger percentage of the power consumption than when running at full plant capacity. A vivid understanding of the principles governing power consumption provides a strong incentive to undertake further research on means for reducing friction.

Closing the Gap Between Research and Application

While there may have been some lack of understanding in the distant past between the infra-scientific and ultra-practical groups, there is every indication today that no such obstacle remains. Both groups are coöperating in the endeavor to meet half way. The recent lectures at the Institute were attended (*Concluded on page 198*)

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The Institute publishes a variety of bulletins, as well as a catalogue of general information essential to the entering student. The Technology Review Bureau will be glad to send, gratis and post free upon request, one or more copies of any publication listed below, or to forward any special inquiry to the proper authority.

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THE OIL-SHED FALLACY

(*Concluded from page 196*)

by a surprising number of representatives of the practical art of lubricating, many of whom weathered the mathematics and remained to contribute helpfully.

A Survey Committee on Lubrication was appointed by the American Society of Mechanical Engineers about a year ago, to determine the present need of the industries with respect to research on lubrication. In their final report, this Committee approved and extended the program of the Special Research Committee on Lubrication, recommending as the most important problems: (1) hydrodynamic lubrication; (2) oiliness, wear, and seizure; (3) physical properties of lubricants; and (4) thermal problems of lubrication.

All that now appears necessary to close the gap between research and application is to go full steam ahead with the research.

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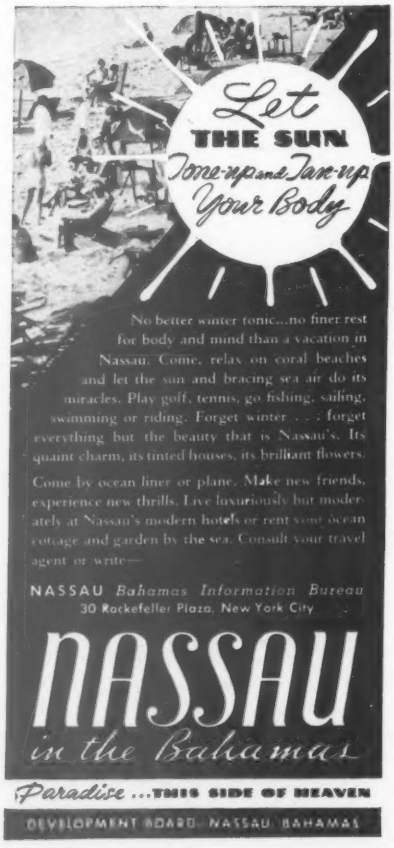
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TREND OF AFFAIRS

(*Concluded from page 178*)

20,000 feet, he suggests consideration of some means for equalizing pressure. Army flyers using oxygen masks at altitudes of approximately 20,000 feet have found, however, that as long as they had sufficient oxygen they felt no discomfort from the decrease in atmospheric pressure.

It is interesting to note that the effects of low pressure and reduced oxygen supply indicated by nausea, headache, earache, or prostration, are immediate in some persons, while others feel them only after a return to normal pressure. The rarefied atmosphere from 14,000 to 16,000 feet causes some individuals to become abnormally irritable and quarrelsome, an effect which, strangely enough, usually appears several hours after exposure to the conditions which cause it.

The responses of the body in compensating for variations in atmospheric pressure have been cited by Dr. Morris Fishbein, editor of the *Journal* of the American Medical Association, as a subject of great interest. At high altitudes, he explains, there is an immediate contraction of the spleen, an effect which forces more blood cells from the spleen into the blood stream to assist in carrying the reduced supply of oxygen to the body tissues. Should the low pressure continue for a considerable period, the bone marrow joins the laboring spleen in its task, and the red blood cells are permanently increased in number, until the distribution of oxygen in the tissues and organs is balanced.

The Institute of Aeronautical Sciences, aware of the imperative need for thorough research and advice from the physiological point of view, has already taken steps to interest the commercial air lines and the Army and Navy air services in a comprehensive study of the entire problem.

FOR SHARPENING YOUR WITS

(*Continued from page 185*)

through which a body falls during t seconds under an acceleration g:

$$s = \tfrac{1}{2} g t^2.$$

Solve for t, obtaining: $t = \sqrt{\frac{2s}{g}}$.

We were told that when the time was half a second less, the space through which the rock had fallen was only half as great. Consequently, we have another equation:

$$t - \tfrac{1}{2} = \sqrt{\frac{s}{g}}.$$

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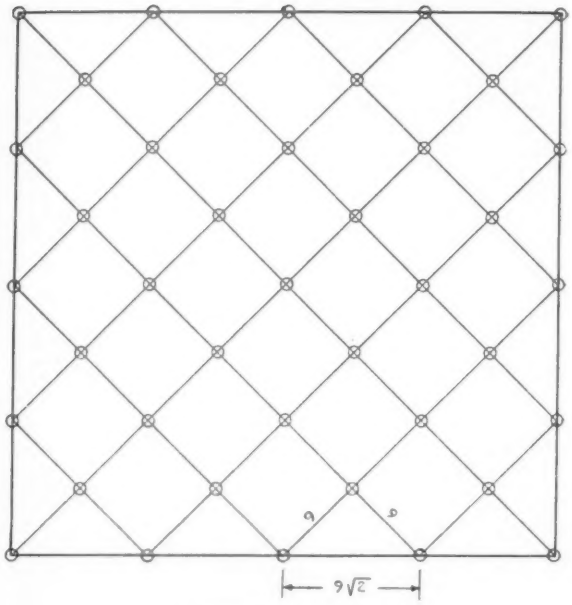

Fig. 1. Solution of the tree problem

Eliminating t from these last two equations and solving for s in terms of g, being careful to make no mistakes either in the algebra or the arithmetic, we obtain $s = 1.4571074\ g$. Now if g be taken as 32.2 to three figures, we get $s = 46.9$ to three figures. Thus, the man's roof was 47 feet high and he must have dropped his rock from a three- or four-story house.

The young farmer can get 41 trees on his square tract of land. Figure 1 shows how to do it. He should begin by marking off the two diagonals of the tract and planting a tree in the center, where they intersect. By drawing other lines parallel to the diagonals at distances of nine feet from each other (and from the diagonals, of course) he will form other intersections where trees may be planted. That there will be room for the 41 intersections in his plot is indicated by the dimensions given for the triangle at the bottom of Figure 1. To obtain this total it is necessary that the distance $9\sqrt{2}$ be contained four or more times in one side of the square plot. Since $4 \times 9\sqrt{2}$ is only 50.91, it is clear that 52 feet, two inches, along each side of the square will allow for this arrangement.

Other procedures do not allow so many trees: If the young man plants six rows of six each, he will have but 36 trees; if he plants a row of six along one edge, a row of five as near as possible to the first row, neighboring that, a row of six, and alternates thus across his lot, he will get only 39 trees.

The problem of the truck drivers and their midnight refreshment is an example of the fact that, while we cannot solve two equations for three unknowns, we may, nevertheless, sometimes solve them for some desired combination of the unknowns. By letting s, c, and d stand for the unit prices of sandwiches, coffee, and doughnuts, respectively, we can set up the following computation:

First truck driver's check, $4s + c + 10d = 85$.

Second truck driver's check, $3s+c+7d=70$.
Subtracting the second equation from the first and solving for s gives:

$$s=15-3d.$$

Substituting this value for s in the second truck driver's equation above and solving for c gives:

$$c=25+2d.$$

Now, the third truck driver's meal may be described thus:

$$s+c+d.$$

If, for the first two terms in this expression, we substitute the values obtained for s and c, we get:

$$(15-3d)+(25+2d)+d.$$

In this last expression the d's immediately cancel out, leaving 40 as the number of cents the third truck driver should have paid for his meal.

The fastest way to solve the problem about suburbanite Jones and his early trip home is to look at the matter from the standpoint of the chauffeur. He left the house at the usual time and was saved ten minutes on the round trip by going only part of the way to the station. Since he always drove at the same speed, this ten minute saving on the round trip must have come about by shortening the time by five minutes each way. He, therefore, drove to within five minutes of the station. Since his habit was to arrive at the station at five o'clock, he must have driven until five minutes of five. That means that Mr. Jones walked until five minutes of five. As he began walking at four o'clock, he walked 55 minutes. That's all there is to that.

The problem of the four tennis players is not quite so simple, even if you don't make any wasted motions. It turns out that the lawyer's name was Piff. The first set ended in a score of 6 to 4, which indicates that an even number of games was played in that set, and that the last game of the set was not served by the side which served first. This last game was lost by Piff (on his own service), so Piff was not the broker, for the broker's side served first. Since Riff bet the broker on the match and Biff lent the broker a racket, it is clear that neither of these two is the broker. If neither Piff, Riff, nor Biff is the broker, then Tiff must be. Since the broker's side served first and the other side lost the first set, the broker's side won the first set. From the final score of 6 to 4, 3 to 6, 6 to 4, we see that the broker's side lost the second set and, therefore, the first game of the third set was served by the broker's opponents. Since the advertising man served this game, he must have been the broker's opponent, and we were told that the lawyer was the broker's opponent. This leaves only the publisher to be the broker's partner. Since the first set went to Biff's side, Biff must be either the broker or his partner, and since Biff lent the broker a racket, he can't be the broker and must be the broker's partner, the publisher.

As Riff bet the broker on the match, he must have been the broker's opponent and must, therefore, have been either the advertising man or the lawyer. Since he was a better player than the lawyer, he must have been the advertising man. This leaves only Piff to be the lawyer.

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4. Maximum Resistance to Structural Breakdown
5. Smooth Running
6. Maximum Traction
7. High Resistance to Side Wear
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Let us send you the Air Commerce Bulletin (left) describing the Casey Jones test with Condor V-Belts and our latest General Catalog and V-Belt Engineering Data Book (right) giving full particulars on Condor Whipcord V-Belt construction.

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A *New* G-R Precision Condenser

Temperature Coefficient of Capacitance: 22 parts per million (+0.0022% per degree C)

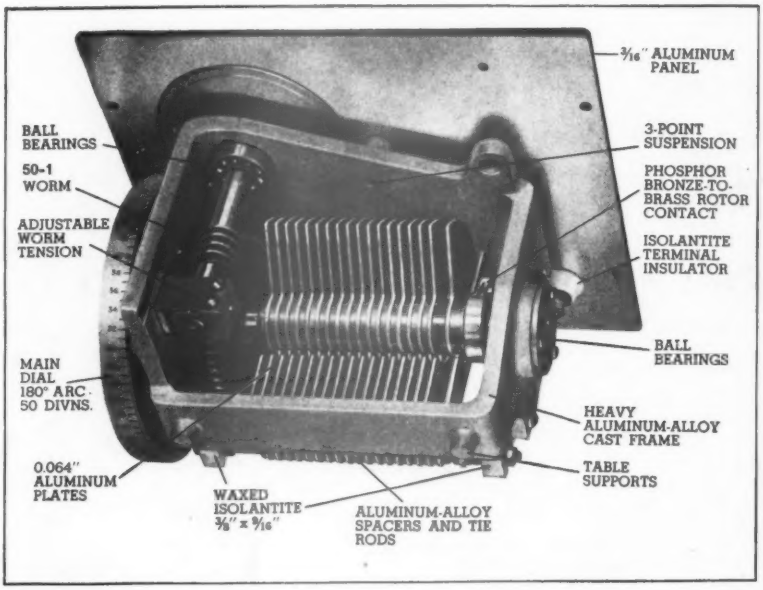
Figure of Merit $R\omega C^2$: 0.04×10^{-12} (constant over audio range from 500 cycles)

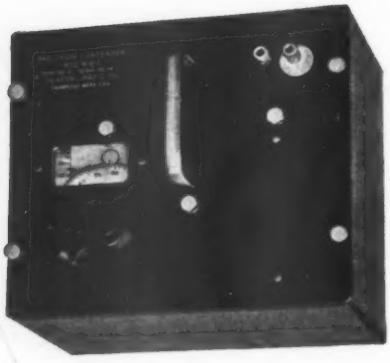
Residual Resistance at 1 Megacycle: 0.02 ohm

Inductance: 0.06 μh

Figure of Merit Unchanged up to 75% Relative Humidity

Vernier Can Be Read to 1 part in 20,000





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for complete details. Either model can be shipped from stock. *Address:*

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FOR almost 20 years the General Radio Type 222 Precision Condenser has been the commercial standard of variable capacitance. The New Type 722 Condenser, with all of the mechanical and electrical improvements shown, now replaces the Type 222.

These unique improvements include: heavy cast frame, spacers and tie rods of aluminum alloy resulting in remarkably low temperature coefficient; worm and worm shaft milled from one piece of steel, reducing worm correction; ball bearings at all important points; phosphor bronze-to-brass rotor contactor eliminating contact through bearings; large, flat-plate vernier with well-spaced scale.

The Type 722 Condensers are supplied in two models:

Type 722-H 45 $\mu\mu$f minimum—1400 $\mu\mu$f maximum—**$90.00**
Type 722-F 40 $\mu\mu$f minimum— 500 $\mu\mu$f maximum—**$85.00**
including calibration at 26 points accurate to 1 $\mu\mu$f or 0.1%.
Worm correction calibration, accurate to 0.1 $\mu\mu$f or 0.1%—**$35.00 additional.**

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